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TWENTY-FIFTH ANNUAL REPORT

OF THE

ONTARIO BUREAU OF MINES, 1916

BEING

VOL. XXV., PART I.

CONTENTS:

	PAGES
Statistical Review	1-51
Mining Accidents	52-65
Mines of Ontario	66-162
Iron Deposits of Hunter Island with notes on the Gunflint Lake Area	163-191
Iron Pyrites Deposits in Southeastern Ontario	192-199
A Study of Certain Minerals from Cobalt, Ontario	200-243
The Boston Creek Gold Area	244-259
The Goodfish Lake Gold Area	260-263
The Kowkash Gold Area	264-274

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CONTENTS

PART I.

PAGE

LETTER OF TRANSMISSION.....

INTRODUCTORY LETTER .....

STATISTICAL REVIEW

Production for 1915 1
Table I, Mineral Statistics of Ontario for 1915 3
Table II, Mineral Production, 1911 to 1915 4
Table III, Total Production of Metals in Ontario 5
Legislation 5
Dividends 5
Table IV, Dividends and Bonuses by Silver and Gold Mining Companies to December 31st, 1915.... 6
Gold 7
Porcupine 7
Other Gold Areas 8
New Prospects 8
Gold Production, 1910-1915 8
Producing Gold Mines, 1915 9
Silver 9
Table V, Silver Production, Cobalt Mines, 1904 to 1915 10
Producing Silver Mines, 1915 11
Metallurgy 12
Smelters and Refineries 12
Table VI, Total Production Cobalt Mines, 1904 to 1915 13
Copper 14
Nickel-Copper Producers, 1915 .. 14
Table VII, Nickel-Copper Mining, 1910 to 1915 14
Nickel 15
Table VIII, Nickel-Copper Ore raised in 1915 15
Iron Ore 15
Iron Mining Companies, 1915..... 16
Pig Iron and Steel 16
Table IX, Production Iron and Steel, 1911 to 1915 16
Makers of Pig Iron, 1915 17
Molybdenite 17
Molybdenite Producers, 1915 17
Localities where Molybdenite occurs 18
Addington county 18
Victoria " 18
Renfrew " 19
Haliburton " 20
General 20
Construction Materials 22
Brick, Tile, Sewer Pipe, and Pottery 22
Labor and Fuel Costs 22
Brick and Tile-making Plants.. 23
Pottery Plants 26

PAGE

Sewer Pipe 27
Sewer Pipe Manufacturers 27
Lime 27
Lime Producers 27
Portland Cement 28
Portland Cement Plants 28
Sand and Gravel 28
Sand and Gravel Operators 29
Stone 29
Granite, Marble and Trap 30
Quartz 30
Limestone and Sandstone 30
Arsenic 31
Calcium Carbide 32
Corundum 32
Feldspar 32
Graphite 33
Graphite Mines 33
Gypsum 34
Gypsum Mines 34
Iron Pyrites 34
Iron Pyrites Shippers, 1915 34
Mica 35
Natural Gas 35
Natural Gas Producers 36
Pipe Line Companies or Distributors only 38
Petroleum 39
Petroleum and Petroleum Products, 1911 to 1915 40
Salt 40
Salt Companies 41
Talc 41
Mining Companies 41
Mining Companies Incorporated in 1915 42
Mining Companies Licensed in 1915 43
Mining Divisions 44
Mining Revenue 44
Mining Lands sold and leased.... 45
Royalties 45
Mining Tax Act 46
Provincial Assay Office 47
Tariff of Fees for Analyses and Assays 49

MINING ACCIDENTS IN ONTARIO IN 1915

General 52
Table of Accidents 53
Analysis of Fatalities at Mines.... 53
Table of Fatal Accidents in Mines, Metallurgical Works and Quarries, 1901 to 1915 54
Cause and Place of Fatalities 54
Cause and Place of Non-Fatal Accidents at Mines 56

PAGE
Falls of Ground 57
Shaft Accidents 57
Accidents from Explosives 58
Miscellaneous Accidents Underground 58
Surface Accidents 59
Prosecutions 59
Rules of Canadian Copper Company 59
Signal System of Canadian Copper Company 60
Accidents at Metallurgical Works and Quarries 62
Table of Fatal Accidents in or about the Mines, 1915 64
Table of Fatal Accidents at Metallurgical Works, 1915 64

MINES OF ONTARIO

I. Northwestern Ontario

Bannerman and Horne Quarries .. 66
Big Master, Jubilee and Laurentian 66
Cameron Island Mine 66
Hewitson and Johnson Claims... 67
Intercities Quarries 67
Mather and Beveridge Soapstone Claims 67
Northern Pyrites Mine 67
Olympia Mine 68
St. Anthony Mine 68

II. Sudbury and North Shore and Michipicoten

Algoma Steel Corporation:
Helen 69
Magpie 69
Canadian Copper Company 69
Canadian Copper Co. Smelter.. 69
Crean Hill 70
Creighton 70
Dill Quartz Quarry 72
Vermilion Mine 73
Mond Nickel Company 73
Bruce Mines 73
Garson Mine 74
Kirkwood 74
Levack Mine 75
Victoria Mine 76
Worthington 76
Other Nickel Properties:
Howland Mine 77
Mount Nickel 77
Miscellaneous Mines:
Goudreau Mine 77
Long Lake Gold Mine 78
Massey Mine 79
Moose Mountain 79
Quarries:
Daniels Quarry 80
East Neebish Quarry 80
Willmott & Co., Quarry 80

III. District of Timiskaming

Gold in Beatty, Munro and Maisonville Townships:
Cartwright 80
Croesus 81
Boston Creek 81
Kirkland Lake Gold Area:
Goodfish 81
Kirkland Lake 82
La Belle Kirkland 82
Lake Shore 82
Lucky Cross 82
Swastika 82
Teck-Hughes 83
Tough-Oakes 83
Smith-Labine 85
Porcupine Gold Area:
Anchorite 85
Dobie 85
Dome 85
Dome Extension 89
Hayden 90
Hollinger Consolidated Mines, Limited 90
Canadian Mining and Finance Company, Limited 90
Hollinger Gold Mines, Limited. 91
Acme 94
Millerton 96
Maidens-McDonald 97
McIntyre 97
McIntyre-Jupiter 99
North Thompson 99
Porcupine Crown 100
" Imperial 100
" Miracle 100
" Vipond 101
Premier-Langmuir 102
Schumacher 102
Triumph 103
Dundonald and Clergue Townships:
Alexo Nickel Mine 103
Timagami Forest Reserve:
Golden Rose 103
Rand Syndicate 104
Silver Mines of Cobalt and Vicinity:
Adanac 104
Aladdin 104
Alexandra 104
Beaver 104
Buffalo 105
Calumet and Montana 105
Casey Cobalt 106
Cobalt Mountain 106
Casey Seneca 106
Cobalt Comet 108
Cobalt Reduction Company..... 108
Columbus 108
Coniagas 108
Crown Reserve 109
Dominion Reduction Company Customs Mill 110
Genesee 110
Glen Lake 110
Hudson Bay 111
Kerr Lake 111
La Rose Consolidated 112
La Rose 112
Lawson 112
Princess 112
University 112

PAGE
McKinley-Darragh-Savage 113
Mercer 114
Meteor 114
Mining Corporation of Canada.. 114
National 117
Nipissing 117
Northern Customs Concentrators Limited 119
O'Brien 119
Ophir 119
Penn-Canadian 120
Peterson Lake 120
Right of Way 121
Rochester 121
Seneca-Superior 121
Shamrock 122
Silver Queen 122
Temiskaming 122
Trethewey 122
Twentieth Century 123
Elk Lake:
Mapes-Johnston 123
Paragon 123
Gowganda:
Barbara Mine 124
Bishop 124
Crews-McFarlan 124
Hewitt Lake 124
Miller Lake-O'Brien 124
Powerful 125
Reeve-Dobie 125
Lorrain and South Lorrain:
Bellellen 125
Currie 125
Giroux Claim 126
Keeley 126
Tallen 126
Maple Mountain:
Rubicon 126
Taylor 126
White Reserve 127

IV. Eastern Ontario

Iron Pyrites:
Caldwell 127
Nichols Chemical Company 127
Queensboro Mine 128
Iron:
Canada Iron Mines, Limited... 128
Gold:
Cordova 128
Golden Fleece 128
Ore Chimney 129
Ore Mountain 129
Talc:
Connolly Mine 129
Eldorite Limited 129
Gillespie Mill 130
Henderson Mine 130
Fluorite 130
Lead:
Galetta Mine 130
Feldspar:
Canadian Feldspar Corporation, Limited 131
Hurlburt 131

PAGE
McIntyre Prospect 131
Richardson Mine 131
Victoria Feldspar Quarry 132
Mica:
Anglin Mine 132
Grierson and Gallagher 132
Lacey Mine 132
Sidney H. Orser Mica Company 133
Scott Mine 133
Taggart Mine 133
Trimming and Splitting 133
Molybdenite 134
Concentrators 134
Belgian Syndicate 135
Burns Prospect 135
Callioux Prospect 135
Jamieson 135
Legree 136
O'Brien 136
Orr 136
Paterson 136
Richardson Prospect 136
Russell 137
Sheffield 137
Snake Lake 137
Spain 137
Treasure Hill Mine 138
Warren 138
Wilson 138
Graphite:
Black Donald 138
Globe 139
National 139
Corundum 140
Marble:
Ontario Marble Quarry 140
White Marble Co. of Canada, Limited 140
Quarries:
Britnell and Company 140
Canada Cement 140
Canada Lime Company 141
Crushed Stone, Limited..... 141
Crookston 141
Delta Lime Company 141
Eganville Quarry 141
Gosselin 142
Gordon & Son 142
Kingston 142
McMillan 142
Mille Roches 142
Ontario Rock Company 142
Point Anne 143
Pembroke 143
Renfrew Quarry 143
Rideau Canal Supply Co. 143
H. Robillard & Son 143
Street and O'Brien 144
Toronto Brick Company 144

V. Southwestern Ontario

Quarries:
Amherstburg Quarry 144
Beachville White Lime Co..... 144
Brown Quarry 144
Canada Crushed Stone Corporation 144

PAGE
Canada Cement Co. 145
Canadian Quarries, Limited 145
Coast and Lakes Contracting Corporation 145
Chalmers Quarry 146
Cook Quarry 146
Empire Limestone Company 146
Fleming Quarry 146
Gallagher Lime & Stone Co. 146
Gravenhurst Quarry 147
Hagersville Crushed Stone Co... 147
Hagersville Contracting Co..... 147
Harrison Quarry 147
E. Harvey, Limited 147
Hurst Quarry 147
Logan Quarry 148
Longford Quarry 148
Marshall Quarry 148
McCormick Quarry 148
McKay and McPherson 148
Michigan Central Quarry 148
Oliver-Rogers Quarry 149
Queenston Quarry Co. 149
F. Rogers and Company..... 149
Standard Crushed Stone Co. ... 149
Standard White Lime Co. 149
St. Marys Portland Cement Co.. 150
St. Marys Horseshoe Quarry... 150
Thames Quarry Company 150
Toronto Lime Company 150
Wentworth Quarry Company... 151
Gypsum:
Caledonia Mine 151
Carson Mine 151
Crown Gypsum Co. 151

VI. Ontario in General

Blast Furnaces:
Algoma Steel Corporation..... 152
Canadian Furnace Company.... 152
Standard Iron Company 153
Steel Company of Canada..... 153
Refineries:
Canadian Smelting and Refining Company 153
Coniagas Reduction Co., Limited 153
Deloro Mining and Reduction Company 154
Electro Zinc Company, Limited. 155
Metals Chemical, Limited 156
Sand and Gravel:
Washing Plants 156
Armstrong Supply Co., Limited. 156
Hamilton Sand and Gravel, Limited 157
Windsor Sand and Gravel Company, Limited 157
Inspection of Excavations 158
Eastern Ontario and Niagara Peninsula 158
Southwestern Ontario 161

IRON DEPOSITS OF HUNTER ISLAND WITH NOTES ON THE GUNFLINT LAKE AREA

Introduction 163
Previous Geological Work in the Area 163
PAGE
Topography 165
Laurentian 166
Keewatin and Huronian 166
Couchiching 167
Iron Deposits of Hunter Island 167
This Man Lake 169
Claim R-343 169
Claim 928-X 170
Claim 968-X 171
Island N.E. of 968-X 171
Claim 944-X 172
Claim 24-X 173
Claim 25-X 173
Next Man Lake 174
Sarpedon Lake 176
Area between Sarpedon and Carp Lakes 177
Pewabic Lake 177
Area between This Man and Emerald Lakes 178
Carp Lake 178
Emerald Lake 180
Big Rock Lake 181
Otter Track Lake 182
Jasper Lake 184
Sagaaagons Lake 184
Iron Deposits in the Gunflint Area.... 185
Waterpowers 188
Fish 191
Game 191
Forests 191

IRON PYRITES DEPOSITS IN SOUTH-EASTERN ONTARIO

Introduction and History 192
List showing the Locations of Pyrite Deposits in Southeastern Ontario. 194
Brockville Section:
Brockville Chemical Co., No. 1... 194
Sloan Prospect No. 2 195
Shipman Prospect, No. 3 195
Lanark County:
McIlwraith Mine, No. 4 195
Ladore Prospect, No. 5 195
Bannockburn Mine, No. 6 195
Hungerford Mine, No. 7 196
The Canada Mine, No. 8 196
The Hungerford Western Extension, No. 9 197
The Ontario Sulphur Mines, Limited, No. 10 197
The Queensboro Mine (Blakely), No. 11 197
The Canadian Sulphur Ore Company's Pyrites Mine, No. 12 ... 197
The Davis or Palmer Deposit, No. 13 198
The Farrell Deposit, No. 14 198
The McKenty Prospect, No. 15.. 198
The Little Salmon Deposit, No. 16 199
Gunter Property, No. 17 199
Snooks Prospect, No. 18 199
Stalker Prospect, No. 19 199
The Foley Deposit, No. 20 199
The Caldwell Prospect, No. 21.... 199

A STUDY OF CERTAIN MINERALS FROM COBALT, ONTARIO

PAGE

Introduction 200
Methods of Microscopic Examination and Separation 201
Methods of Chemical Analysis 202
Native Silver 203
Paragenesis 205
Argentite Crystals, Casey-Cobalt Mine 206
Argentite, O'Brien Mine 208
Galena Crystals, O'Brien Mine 208
Chalcocite, Foster Mine 209
Breithauptite Association, Hudson Bay Mine 209
Etching Methods for Breithauptite.. 210
Microstructure and Order of Deposition of the Breithauptite and Associated Minerals 211
Separation of the minerals for Analysis 214
Isolation of Breithauptite 216
Isolation of Niccolite 217
Isolation of Cobaltite 218
General Conclusions regarding Breithauptite and Associated Minerals. 219
Smaltite and Chloanthite Crystals, Foster Mine 219
Cobaltite Crystals, Columbus Claim. 221
Löllingite, Kerr Lake Mine 223
Arsenopyrite Crystals, O'Brien Mine 227
Rammelsbergite, University Mine.... 228
Glaucodot, O'Brien Mine 230
Matildite-Galena Intergrowth, O'Brien Mine 232
Proustite from Cobalt, O'Brien Mine 233
Polybasite Crystals, O'Brien Mine.. 234
Pink Carbonate 236
Symplesite, Penn-Canadian Mine... 236
Earthy Scorodite and Erythrite, Temiskaming and Hudson Bay Mine 240
On Isomorphism as Displayed by Certain Minerals from Cobalt 240
Order of Deposition of Cobalt Minerals 242

BOSTON CREEK GOLD AREA

Introduction 244
Early Exploration of the Area 245
Topography 246
General Geology 246
Keewatin 247
Timiskamian 249
Algoman 250
Keeweenawan 251
Glacial and Recent 251

PAGE

Economic Products:
Gold 251
Pyrite 252
Copper 252
Iron 252
Building Stone 253
Timber and Agriculture 253
Water Powers 253
Origin of the Gold Deposits 253
Description of the Gold Prospects:
R. A. P. Mining Company 254
Currie 255
Miller-Independence 255
McRae 256
Connell-McDonough 258
Cullen-Renaud 258
Authier-Charlebois 258
Charest 259
Conclusion and Acknowledgments... 259

GOODFISH LAKE GOLD AREA

Introduction 260
Geology:
Keewatin 260
Quartz-Feldspar Porphyry 260
Timiskamian Series 261
Economic Geology 261
La Belle Kirkland 262
Costello 263
Martin 263
Brennan 263
Brennan-Bowes group 263

KOWKASH GOLD AREA

Introduction 264
Location 265
Early Exploration and History 265
Topography 267
General Geology 267
Keewatin 267
Laurentian ? 268
Timiskamian 268
Algoman ? 268
Keweenawan 269
Glacial and Recent 269
Economic Geology 269
Iron 270
Gold 270
Other Minerals 270
Other Resources 271
Description of Gold Claims 272
Dodds 272
Richardson-Loudon-Ogilvie 273
Dawson 273
Devanney 273
McFarlane-Manion 273
Conclusions 273

ILLUSTRATIONS

	PAGE
New shaft and rock house under construction, Creighton mine	71
Completed shaft and rock house, Creighton mine	72
This Man lake from outcrop of ore on R-343	170
Banded hematite on claim 944-X	172
Island on Next Man lake showing sericite schist in foreground, and iron ore in background	174
Iron ore on Next Man lake	175
View from the head of Sarpedon lake	176
Folded iron ore, Merritt's camp	178-179
Cliff of iron ore, showing major folds and rounded surfaces	181
Near view of same outcrop, exhibiting crumpling of iron ore	182
A closer view of outcrop shown on page 182	183
Otter Track lake, looking northeast from United States side	183
Keewatin (?) outcrop on railway east of Gunflint lake	188
Keewatin (?) outcrop, showing major folding on north side of Gunflint lake	189
Falls on the outlet of Gunflint lake	189
Waterfall on the outlet of Saganaga lake	190
Skeleton crystals of dyscrasite in native silver	203
Inclusions of argentite in native silver	203
Cross-section of a rich silver vein, showing silver replacing arsenides and calcite	204
Dendritic growths of smaltite with native silver in calcite	206
General structure of breithauptite, also niccolite inclusions showing in bright relief	210
Arborescent areas of breithauptite	211-212
Light coloured breithauptite and cubes of cobaltite in ground mass of porous niccolite	213
Silver veinlets cutting nickel-cobalt minerals and the calcite filling	214
Native silver, filling cleavage cracks in calcite	215
Intergrowth of smaltite and cloanthite	216
Inclusions of gersdorffite (?) in ground mass of a cobaltite crystal	222
Löllingite specimen (natural size)	224
Etched löllingite surface showing constituents	225
Prismatic crystals of rammelsbergite in niccolite	230
Concentric structure representing an intergrowth of arsenides	231
Matildite inclusions in ground mass of galena	231
Boston Creek station and vicinity	245
Volcanic fragmental rock near Boston Creek station	248
Granite with fragments of greenstone and narrow dikes cutting both (Authier claim)	250
Shaft and power plant, R.A.P. Mining Co.	254
Power plant and mill at Miller-Independence property	256
Small steam plant on McRae property	257
Gold bearing quartz vein dipping 20° N.	257
Prospector at discovery of native gold in veinlets in the granite	258
La Belle Kirkland mine	262
Kowkash station, National Transcontinental railway	265
Prospectors at Johnson creek railway crossing	266
Kettle lakes in terminal moraines near Kowkash station	269
Diamond drilling, Onaman iron range	270
Speckled trout 16 to 20 inches long, Kowkash region	271
Howard falls, Kawashkagama (Kowkash) river	272

SKETCH MAPS, PLANS AND DIAGRAMS

	PAGE
Diagram showing weekly fluctuation of silver prices for 1915	9
Signal system, No. 2 shaft, Creighton mine	61
Flow sheet of mill at Tough-Oakes mine	84
Framing of No. 3 shaft, Dome Mines	87
Framing of six-compartment shaft, Hollinger Consolidated Mines, Limited	92
Flow sheet, Cobalt Reduction Company	107
Flow sheet Cobalt Lake mill	116
Geological sketch map of Hunter island iron ore deposits	164
Map showing mining claims on Hunter island	168
Geological sketch map of Gunflint Lake area	186
Map of part of southeastern Ontario, showing general geology and location of deposits of iron pyrites	193

PAGE
Veinlet of argentite with fibrous native silver at the sides 205
Crystallized argentite, Casey-Cobalt mine 207
Sketch of smaltite-cloanthite intergrowth 220
Diagram of löllingite specimen (natural size) 224
Arsenopyrite crystal, O'Brien mine 228
Diagram of rammelsbergite specimen 229
Drawing of crystallized rammelsbergite 229
Polybasite, O'Brien mine 235
Diagram of part of vein from Silver Bar mine 242
Sketch map showing location of gold properties in Boston Creek and Goodfish Lake areas 244
Sketch map showing position of Kowkash relative to other mineral areas in northern Ontario 264

GEOLOGICALLY COLOURED MAPS

(In pocket on inside of back cover)

Map No. 25*a*.—Kowkash Gold Area, district of Thunder Bay, scale: 4 miles to the inch.
Map No. 25*d*.—Boston Creek Gold Area, district of Timiskaming, scale: ¾ mile to the inch.
Map No. 25*f*.—Goodfish Lake Gold Area, scale: 30 chains to the inch.

LETTER OF TRANSMISSION

To His Honour Sir John Strathearn Hendrie, C.V.O.,

Lieutenant-Governor of the Province of Ontario.

Sir,—I have the honour to transmit herewith, for presentation to the Legislative Assembly of the Province of Ontario, the Twenty-fifth Annual Report of the Bureau of Mines.

I have the honour to be, Sir,

Your obedient servant,

G. H. Ferguson,

Minister of Lands, Forests and Mines.

Department of Lands, Forests and Mines,
Toronto, 1916.

INTRODUCTORY LETTER

To The Honourable George Howard Ferguson, K.C.,

Minister of Lands, Forests and Mines.

Sir,—I have the honour to present to you herewith, to be transmitted to His Honour the Lieutenant-Governor in Council, the Twenty-fifth Annual Report of the Bureau of Mines consisting of three Parts, being for the calendar year 1915.

Part I comprises a Statistical Review of the Mining Industry of Ontario for 1915 by W. R. Rogers; a report on the Mining Accidents of the year by T. F. Sutherland, Chief Inspector of Mines, and Inspectors E. A. Collins and James Bartlett; an account of the operating mines in the Province by Mr. Sutherland and Inspectors Collins, McMillan and Bartlett; a description of the Iron Deposits of Hunter Island with notes on the Gunflint Lake Area, by A. L. Parsons of the University of Toronto; notes on Iron Pyrites Deposits in Southeastern Ontario, by P. E. Hopkins; a Study of Certain Minerals from Cobalt, Ontario, by H. V. Ellsworth, of the University of Toronto; reports on Boston Creek Gold Area and the Goodfish Lake Gold Area, by A. G. Burrows and P. E. Hopkins of the Geological staff of the Bureau; and a preliminary report on the Kowkash Gold Area, by P. E. Hopkins. The several illustrated reports of a geological nature are accompanied by appropriate maps and plans, both coloured and in black and white.

Part II, entitled Lead and Zinc Deposits in Ontario and in Eastern Canada, by W. L. Uglow, was prepared for the purpose of bringing together all the available information on the subject in view of the increased demand for these metals occasioned by the war. Dr. Uglow was particularly fitted for this task, having had experience in the investigation of deposits of these metals in the State of Wisconsin. He also made private examination of several properties in Ontario. The mines and prospects are described individually, and the report is accompanied by two geologically coloured maps.

Part III, a description of the Geology of Kingston and Vicinity, by Prof. M. B. Baker, of Queen's University, is accompanied by a contoured map, geologically coloured, of the southern part of Frontenac county. This part of eastern Ontario is well mineralized, mica and feldspar being mined extensively. The report is accompanied by two appendices by officers of the Geological Survey of Canada: Appendix I, the Ordovician Limestones of the Kingston area, by E. M. Kindle; Appendix II, a Synopsis of the Common Fossils of the Kingston area, by A. E. Wilson and K. F. Mather.

The statistical tables printed in Part I of the Report show the decline in value of the mineral output, which was occasioned in 1914 by the outbreak of war, to have continued in 1915 only so far as the non-metallic production is concerned. A great increase in the production of metals more than offsets this decline, so that the total value of the mineral production of the Province for 1915 exceeds that of the former record year, 1913, by over one million dollars. The greatest increase

is in the value of nickel-copper matte which approached $21,000,000 as compared with a little over $7,000,000 in 1914. The advance in output and a higher valuation of the nickel and copper contents account for this unprecedented increase. Gold also showed an increase in output of nearly $3,000,000, which is credited largely to the Porcupine camp. The newer gold camps of Kirkland Lake, Munro, Boston Creek and Kowkash promise soon to add to the gold production of the Province. Molybdenite, used in tool steel manufacture, was produced for the first time in Ontario in appreciable quantities. Concentrators have been erected for treating this ore, and ferro-molybdenum is about to be manufactured in the Province.

I have the honour to be, Sir,

Your obedient servant,

THOS. W. GIBSON,

Deputy Minister of Mines.

BUREAU OF MINES,
DEPARTMENT OF LANDS, FORESTS AND MINES,
Toronto, 1916.

STATISTICAL REVIEW

of the

MINERAL INDUSTRY OF ONTARIO FOR 1915

By W. R. ROGERS

The Mining Act of Ontario (section 170) requires the owners or operators of all mines, quarries, metallurgical and mineral works in the Province to make returns to the Bureau of Mines, showing the quantity and value of the minerals produced during the year together with such particulars as to number of employees, wages paid, etc., as are necessary for statistical purposes. A penalty is provided for non-compliance with the provisions of the Act, and a further penalty for every day after written notice has been given that the offence continues. Owners and operators are reminded of the importance of supplying complete and accurate information promptly in order that the compilation of statistics for any particular industry may be presented at the earliest possible date in a careful and authoritative manner.

There are facts regarding the importance of several of the mineral products of the Province, perhaps not widely known in some instances, which are worthy of emphasis. The largest high-grade talc deposit on the continent is situated at Madoc; the greatest mica mine, the Lacey, near Sydenham; the largest high-grade feldspar mine near Verona; and the greatest graphite deposit known as the Black Donald mine, near Calabogie. All these non-metallic deposits are located in eastern Ontario in the counties of Hastings, Frontenac and Renfrew. Coming to the metals, Ontario possesses at Sudbury the most valuable nickel deposits in the world. Of these the Creighton ore body is undoubtedly the largest, the highest grade and most important. Cobalt is widely known as the richest silver camp in the world, the value of the output to date approaching that of gold from the Yukon. Ontario also possesses in Porcupine the most promising of the younger gold camps on the continent. During 1915 in the Province of Ontario there were 79 producing mines, 62 of which operated at a profit.

Production for 1915

Industrial depression which set in after the declaration of war in August, 1914, continued to some extent during the early part of 1915, but in the latter part of the year a revival in business was well under way. The mines were worked with feverish activity in order to supply the abnormal demand for metals, particularly nickel and copper. Prices, which are dependent on supply and demand, rapidly advanced.

The steady growth which marked the mineral production of Ontario for a decade prior to 1913, received a severe check in 1914, owing in part to business depression, but chiefly to the outbreak of war in the month of August, and to the resulting disturbances in industrial and financial conditions. In consequence, the 1914 production was 13 per cent. or $6,936,352 less than that of 1913. The year 1915, however, has shown a turn in the tide with a marked increase in production over 1914, amounting to 17 per cent. or $7,949,720. Gold has shown a large in-

crease, offset to some extent by a decrease in silver production. Nickel and copper experienced what would be considered abnormal increases in times of peace. The great demand for these metals for munition purposes together with the impetus of increased prices stimulated production to the limit of capacity of the operating companies.

Among non-metallic substances, there has been a great falling off in the output of construction materials, brick, stone, lime, etc. A sufficient explanation of this decline is found in the fact that the energies of many of our people are turned from the building trades to the manufacture of munitions and to other industries more essential in the vigorous prosecution of the war.

Taking successive five-year periods, beginning with 1891, when the Ontario Bureau of Mines was established, the growth in the mineral production of the Province, expressed in value and by percentages for the several years and periods, has been as follows:—

Year.	Value. $	Growth per cent.
1891.....	4,705,673	
1896.....	5,235,003	.....11.2
1901.....	11,831,086	.....125.9
1906.....	22,388,383	.....89.2
1911.....	41,976,797	.....87.4
1915.....	54,245,679	.....29.2

In Table I a departure from the previous practice of the Bureau is made as regards pig iron and iron ore. Hitherto the total production of pig iron, from imported as well as domestic ore, has been given as that of Ontario. It is possible that this may give rise to erroneous impressions regarding the extent of the iron mining industry of the Province, and it has been thought best to confine the pig iron product of Ontario to the proportion of the output which, on the basis of the number of tons smelted of imported and Ontario ore, may be properly attributable to the latter. The iron ore reported is the quantity only that was exported, the remainder going to the blast furnaces of the Province to be smelted into pig iron. The total production of iron ore is shown under that heading.

Heretofore the low valuation placed on the nickel-copper matte by the producing companies has been accepted for statistical purposes. In 1914 these figures were 11.2 cents per pound for nickel and 7.2 cents for copper. Exact figures of value cannot be obtained, for the reason that nickel-copper matte is not a commodity bought and sold in the open market. The basis of valuation for 1915 has been fixed by the Bureau of Mines at 25 cents per pound for nickel and 10 cents for copper. These figures are conservative in view of the fact that the average price of refined copper in 1915 was about 17 cents, and that the nickel refined in Ontario in 1915 was sold at 40 cents per pound.

The quantities, valuation at the point of production, labour employed and wages paid in connection with the mineral industry of Ontario for the year 1915 are summarized in the following table:—

TABLE I.—MINERAL STATISTICS OF ONTARIO FOR 1915

Product.	Quantity.	Value.	Employees.	Wages.
METALLIC:		$		$
Gold ..... ounces	411,588	8,501,391	2,419	2,206,179
Silver..... "	24,823,660	12,174,312	2,708	2,540,568
Copper ore ..... tons	271	4,418	100	32,266
Copper in matte..... "	19,608	(a) 3,921,600	4,178	3,581,639
Nickel in matte..... "	34,039	(a) 17,019,500		
Iron ore (exported)..... "	88,322	171,345	392	224,306
Pig iron ..... "	(b) 157,888	1,891,400	563	370,978
Cobalt ore..... "	177	21,464	(c)	(c)
Cobalt (metallic) ..... lbs.	111,558	103,746	360	253,540
Cobalt oxide ..... "	314,906	254,447		
Nickel " ..... "	145,323	17,968		
Nickel (metallic) ..... "	11,905	4,762		
Other Nickel and Cobalt compounds ..... "	75,447	9,227		
Molybdenite ore..... tons	192	12,859	95	22,061
Molybdenite concentrates .... lbs.	1,068	1,240		
Total metallic.....	.....	44,109,679	10,815	9,231,537
NON-METALLIC:				
Arsenic, (white, grey and other forms)..... lbs.	4,980,659	148,379	(d)	(d)
Brick (fancy, terra cotta, etc. M	3,758	158,515	344	160,483
" (pressed) ..... "	24,836	217,350		
" (common ..... "	91,967	763,591	1,627	445,726
Tile, drain ..... "	17,837	321,253		
Cement (Portland) ..... bbls	2,302,242	2,534,537	692	425,170
Corundum..... tons	262	31,398	10	9,755
Feldspar..... "	12,649	47,031	66	22,265
Graphite (refined) ..... "	2,534	115,274	78	37,929
Gypsum (crushed, ground and calcined) ..... "	81,172	190,422	139	65,312
Iron pyrites..... "	145,315	353,498	213	177,627
Lime ..... bush	1,340,394	244,953	158	90,808
Mica..... tons	195	33,490	32	12,962
Natural gas..... M cu. ft.	15,211,523	2,622,838	598	382,401
Petroleum (crude)..... Imp. gals.	7,505,478	300,219	(e) 723	(e) 564,950
Pottery	.....	49,387	26	15,280
Quartz ..... tons	95,460	142,354	86	39,581
Salt ..... "	116,648	585,022	242	183,558
Sand and gravel ..... cu. yds.	670,510	178,288	292	87,264
Sewer pipe.....	.....	361,283	223	131,422
Stone (building, marble, trap, etc.)	.....	651,593	726	290,945
Talc (crude) ..... tons	1,720	5,160	40	23,790
" (ground)..... "	9,285	80,165		
Total non-metallic	.....	10,136,000	6,375	3,167,228
Add metallic.....	.....	44,109,679	10,815	9,231,537
Grand Total	.....	54,245,679	17,190	12,398,765

(a) Copper at 10 and nickel at 25 cents per pound in the matte.
(b) Production from Ontario iron ore only.
(c) Included in silver production.
(d) Included with cobalt and nickel compounds.
(e) Employees and wages for petroleum refineries.

In Table II comparative figures are given showing the value of the mineral production of the Province for a five-year period. A rapid development is noted despite a few decreases in individual products and the general set back recorded in 1914, the first year of the war. Among the metals, gold, copper and nickel show the greatest increases. The decrease in pig iron, as already explained, is due to reporting only the pig iron produced from domestic iron ore.

TABLE II.—MINERAL PRODUCTION, 1911 TO 1915

Product.	1911	1912	1913	1914	1915
METALLIC:	$	$	$	$	$
Gold	42,637	2,114,086	4,558,518	5,529,767	8,501,391
Silver	15,953,895	17,671,918	16,579,094	12,795,214	12,174,312
Cobalt	170,890	315,781	420,386	546,479	(a) 379,657
Copper	1,281,118	1,584,310	1,840,492	2,081,332	3,926,018
Nickel	3,664,474	4,736,460	5,250,803	5,136,804	(b)17,042,230
Other Nickel and Cobalt compounds	.....	.....	.....	45,189	9,227
Iron ore	273,539	93,558	138,750	169,427	171,345
Pig iron	7,716,314	8,054,369	8,719,892	7,041,079	1,891,400
Lead	.....	1,290	.....	.....	.....
Molybdenite	.....	.....	.....	.....	14,099
Platinum	.....	80,736	.....	.....	.....
Palladium	.....	147,235	.....	.....	.....
Metallic production	29,102,867	34,799,743	37,507,935	33,345,291	44,109,679
NON-METALLIC:					
Arsenic	74,609	79,297	64,146	116,624	148,379
Brick, common	2,801,971	3,178,250	3,452,352	2,336,207	763,591
" paving, fancy, etc.	86,685	221,986	243,119	237,440	158,515
" pressed	564,630	634,169	919,741	656,944	217,350
Building and crushed stone	892,627	953,839	1,137,153	1,088,862	651,593
Calcium carbide	84,437	120,000	123,100	142,883	(c) .....
Cement, Portland	3,640,642	3,365,659	4,105,455	2,931,190	2,534,537
Corundum	147,158	233,212	137,036	65,730	31,398
Feldspar	51,610	28,916	67,142	55,686	47,031
Fluorspar	200	.....	.....	.....	.....
Graphite	36,492	65,076	93,054	87,167	115,274
Gypsum	32,535	50,246	92,627	221,175	(d) 190,422
Iron pyrites	118,457	71,043	171,687	264,722	353,498
Lime	402,340	381,672	390,600	333,407	244,953
Mica	43,058	57,384	55,264	40,402	33,490
Natural gas	2,186,762	2,268,022	2,362,021	2,346,687	2,622,838
Peat fuel	2,830	725	1,750	2,100	.....
Petroleum (crude)	353,573	344,537	398,051	337,867	300,219
Phosphate of lime	240	.....	.....	3,150	.....
Pottery	50,500	52,445	52,875	25,720	49,387
Quartz	64,405	179,576	130,860	82,544	142,354
Salt	430,835	450,251	474,372	498,383	585,022
Sand and gravel	.....	.....	233,567	151,909	178,288
Sewer pipe	410,064	464,627	600,297	571,756	361,283
Talc	47,725	61,358	125,340	(e) 74,583	(e) 85,325
Tile, drain	349,545	279,579	292,767	277,530	321,253
Non-metallic production	12,873,930	13,541,869	15,724,376	12,950,668	10,136,000
Add metallic production	29,102,867	34,799,743	37,507,935	33,345,291	44,109,679
Total production	41,976,797	48,341,612	53,232,311	46,295,959	54,245,679

(a) Cobalt ore, oxide and metallic Cobalt. (b) Nickel in matte, oxide and metallic Nickel.
(c) Raw materials not all produced in Ontario. (d) Crude Gypsum and Gypsum products.
(e) Crude and Ground Talc.

Although accurate figures of production for the early years of iron and copper mining in Ontario are not available, the amount is negligible as compared with the production since 1891, when statistics were first systematically collected. The total value of metals produced is shown in the following table:—

TABLE III.—TOTAL PRODUCTION OF METALS IN ONTARIO

Metal.	Value to end of 1914.	Value, 1915.	Total Value.
	$	$	$
Gold	14,822,998	8,501,391	23,324,389
Silver	126,550,597	12,174,312	138,724,908
Platinum and Palladium	290,755	.....	290,755
Cobalt (a)	2,039,006	379,657	2,418,663
Nickel (b)	51,400,370	17,042,230	68,442,600
Other Cobalt and Nickel Compounds	45,189	9,227	54,416
Copper	21,161,355	3,926,018	25,087,373
Iron ore	7,679,836	171,345	7,851,181
Pig iron	73,007,072	1,891,400	74,898,472
Lead	117,290	.....	117,290
Zinc	92,410	.....	92,410
Molybdenum	1,675	14,099	15,774
Total	297,208,553	44,109,676	341,318,229

(a) Includes metallic contents of Cobalt Oxide.
(b) " " " Nickel Oxide.

Legislation.—The Workmen's Compensation Act covering mining as well as other industrial operations, came into effect on January 1st, 1915. It vests in a Government-appointed Board the adjustment of compensation for employees who may meet with injuries or be killed in the pursuit of their work. One result of the Act has been the speedy settlement of claims without expensive litigation. The rate paid by mine operators was 3 per cent. of the pay roll. This has been reduced to 2½ per cent. for 1916.

Water power is becoming an important factor in the operation of mines. Of late years there have been clashes between lumbering and water power interests, the former naturally wishing to take advantage of the spring run-off for floating logs, and the latter to store it for use during dry periods. Amendments made by the Rivers and Streams Act, 1915, place authority in the Minister of Lands, Forests and Mines to deal with conflicting interests as they may rise, and to exercise control over water levels.

Dividends:—During the year dividends paid by silver mines operating in the Cobalt area amounted to $4,441,948.08. The total return to shareholders up to the end of 1915 reached $59,670,912.70. Up to the end of 1914 two Porcupine gold mines, Hollinger and Porcupine-Crown, had paid dividends amounting to $2,850,000. During 1915 the Dome, Rea and Tough-Oakes were added to the list. The latter mine is in the Kirkland lake area. The total dividends paid by gold properties to December 31st, 1915, amount to $5,194,875.

TABLE IV—DIVIDENDS AND BONUSES BY SILVER AND GOLD MINING COMPANIES TO DECEMBER 31ST, 1915

Name of Company.	Date of Incorporation.	Authorized Capital.	Capital Stock issued.	Par value per share.	Amount of Dividends and Bonuses declared to end of 1914.	Amount of Dividends and Bonuses declared during 1915.	Total of Dividends and Bonuses declared to Dec. 31, 1915.	Last Dividend or Bonus. Date declared.
SILVER COMPANIES		$	$	$	$ c.	$ c.	$ c.	
Beaver Consolidated Mines, Limited	Feb. 25, 1907..	2,000,000	2,000,000	1.00	470,000 00	120,000 00	590,000 00	Oct. 15, 1915.....
Buffalo Mines, Limited	April 27, 1906..	1,000,000	1,000,000	1.00	2,787,000 00	.....	2,787,000 00	May 28, 1914.....
Casey Cobalt Mining Company, Limited	Dec. 19, 1906..	100,000	100,000	1.00	203,249 33	.....	203,249 33	Apl. 22, 1914.....
†City of Cobalt Mining Company, Limited	Oct. 5, 1906.. / Jan. 7, 1909..	500,000 / 1,500,000	1,500,000	1.00	145,000 00	.....	145,000 00	Apl. 15, 1909.....
†Cobalt Lake Mining Company, Limited	Dec. 22, 1906..	3,000,000	3,000,000	1.00	465,000 00	.....	465,000 00	May 29, 1914.....
†Cobalt Townsite Mining Company, Limited	May 8, 1906..	100,000	45,011	1.00	1,042,259 61	.....	1,042,259 61	Nov. 11, 1914.....
*Mining Corporation of Canada, Limited	Mar. 20, 1914..	2,075,000	2,075,000	1.00	259,375 00	518,750 00	778,125 00	Sept. 30, 1915.....
Cobalt Central Mines Company, Limited	Dec. 13, 1906..	5,000,000	5,000,000	1.00	192,845 00	.....	192,845 00	Aug. 25, 1909.....
Cobalt Comet Mines, Limited, (Drummond)	April 16, 1913..	1,000,000	1,000,000	1.00	103,000 00	27,000 00	130,000 00	Apl. 1 1915.....
Cobalt Silver Queen, Limited	April 1, 1906..	1,500,000	1,500,000	1.00	315,000 00	.....	315,000 00	Dec. 31, 1908.....
Coniagas Mines, Limited	Nov. 24, 1906..	4,000,000	4,000,000	5.00	7,240,000 00	600,000 00	7,840,000 00	Aug. 1, 1915.....
Crown Reserve Mining Company, Limited	Jan. 16, 1907..	2,000,000	1,999,957	1.00	5,996,279 46	106,128 84	6,102,408 30	July 15, 1915.....
Foster Cobalt Mining Company, Limited	Feb. 14, 1906..	1,000,000	915,588	1.00	45,000 00	.....	45,000 00	Jan. 1, 1907.....
Kerr Lake Mining Company, Limited	Aug. 9, 1905..	40,000	40,000	100.00	5,834,000 00	674,000 00	6,508,000 00	Oct. 13, 1915.....
La Rose Mines, Limited	Feb. 21, 1907..	6,000,000	6,000,000	5.00	5,374,546 84	328,000 00	5,702,546 84	Dec. 10, 1915 .....
McKinley-Darragh-Savage Mines of Cobalt, Limited	April 17, 1906..	2,500,000	2,247,692	1.00	4,404,484 38	269,723 04	4,674,207 42	Nov. 27, 1915.....
Nipissing Mining Company, Limited	Dec. 16, 1904..	250,000	250,000	100.00	13,233,297 25	1,220,000 00	14,453,297 25	Dec. 13, 1915.....
Peterson Lake Silver-Cobalt Mining Co., Limited	April 11, 1906..	3,000,000	2,401,820	1.00	126,095 55	168,127 40	294,222 95	Nov. 26, 1915.....
Right of Way Mining Company, Limited	July 13, 1906..	500,000	500,000	1.00	324,643 93	.....	324,643 93	.....
The Right of Way Mines, Limited	Sept. 11, 1909..	2,000,000	1,685,500	1.00	219,115 20	.....	219,115 20	Nov. 16 1914.....
Seneca-Superior Silver Mines, Limited	Sept. 29, 1911..	500,000	478,884	1.00	645,993 40	335,218 80	981,212 20	Dec. 5, 1915.....
Temiskaming and Hudson Bay Mining Co., Limited	July 29, 1903..	25,000	7,761	1.00	1,940,250 00	.....	1,940,250 00	Nov. 10, 1914.....
The Hudson Bay Mines, Limited	July 16, 1909..	3,500,000	3,200,050	5.00	778,909 42	.....	778,909 42	Aug. 31, 1913.....
Temiskaming Mining Company, Limited	Nov. 16, 1906.. / Jan. 1, 1908..	2,500,000	2,500,000	1.00	1,384,156 25	75,000 00	1,459,156 25	Dec. 31, 1915.....
Trethewey Silver-Cobalt Mine, Limited	May 30, 1906.. / June 1, 1911..	2,000,000	1,000,000	1.00	1,061,998 50	.....	1,061,998 50	June 19, 1914.....
Wettlaufer-Lorrain Silver Mines, Limited	Nov. 30, 1908..	1,500,000	1,416,590	1.00	637,465 50	.....	637,465 50	Sept. 22, 1913.....
Total from Silver Companies	.....	.....	.....	.....	55,228,964 62	4,441,948 08	59,670,912 70	
GOLD COMPANIES								
Dome Mines, Limited	Mar. 23, 1910..	5,000,000	4,000,000	10.00	.....	400,000 00	400,000 00	Nov. 3, 1915.....
Hollinger Gold Mines, Limited	June 28, 1910..	3,000,000	3,000,000	5.00	2,610,000 00	1,560,000 00	4,170,000 00	Dec. 31, 1915.....
Porcupine Crown Mines, Limited	May 26, 1913..	2,000,000	2,000,000	1.00	240,000 00	240,000 00	480,000 00	Jan. 2, 1916.....
Tough Oakes Gold Mines, Limited	July 15, 1915..	3,000,000	531,500	5.00	.....	132,875 00	132,875 00	Nov. 15, 1915.....
Rea Consolidated Gold Mines, Limited	April 5, 1911..	1,000,000	200,000	5.00	.....	12,000 00	12,000 00	.....
Total from Gold Companies	.....	.....	.....	.....	2,850,000 00	2,344,875 00	5,194,875 00	
Total Dividends in 1915	.....	.....	.....	.....	58,078,964 62	6,786,823 08	64,865,787 70	

† Now amalgamated and operated by the Mining Corporation of Canada, Limited.

* This Company operates the City of Cobalt, Cobalt Lake and Cobalt Townsite mines.

Gold

Ontario's gold production has increased steadily since the year 1911, until gold mining is now a well established industry in the Province. The leading position which Ontario assumed in gold production in 1914, among the Provinces of Canada, was firmly established in 1915, when the production was 411,588 ounces of gold worth $8,501,391, an increase of over 53 per cent. over 1914. As formerly, the large increase is credited mainly to the Porcupine camp. Other producers were the Tough-Oakes at Kirkland lake; Croesus in Munro township; Canadian Exploration Company at Long lake, near Sudbury; Cordova Mines in Belmont township, Peterborough county; and, in a small way, Olympia in northwestern Ontario. In addition, there was recovered from the bullion at the gold mines, 77,126 fine ounces of silver worth $38,496.

The employees numbered 2,419, of whom 1,286 worked underground and 1,133 on the surface. They were paid in wages $2,206,179.

Porcupine:—During 1915 there were milled in the Porcupine mills 964,334 tons of ore which yielded a value of $7,472,167 or $7.85 per ton. In addition, 9,693 tons of concentrates were shipped which yielded $97,829, making the total Porcupine production $7,536,275 or 89 per cent. of the whole.

The producing mines were twelve in number. In addition to the larger producers enumerated in the table below there were the Dome lake, Gold Reef, Schumacher, Porcupine Pet and Porphyry Hill.

The following table gives the tonnage milled and values recovered, etc., by some of the large producers for the year 1915:—

Mine.	Tons milled.	Gold produced, ounces.	Total gold value.	(5) Extraction per ton.	Dividends declared.
			$	$ c.	$
Hollinger (3)	334,750	152,673	3,154,992	9 47	1,560,000
Dome	317,740	73,726	1,524,051	4 80	400,000
Acme (4)	106,486	49,933	1,032,205	9 73	.....
McIntyre	101,955	36,094	745,880	7 37	.....
Porcupine Crown (6)	41,326	29,032	599,998	14 02	240 000
Vipond	35,899	11,871	245,372	6 85	.....
Rea (Mines Leasing Co.)	.....	.....	.....	.....	12,000
Total	.....	.....	.....	.....	2,212,000

(3) The Hollinger received in addition $81,730 from 9,500 tons of concentrates.
(4) Ore was treated in the Hollinger mill.
(5) The extraction per ton is based on the total gold and silver recovery.
(6) The Porcupine-Crown milled in addition 5,093 tons of tailings from the first amalgamation mill.

The Northern Canada Power Company, Limited, supply the Porcupine camp with hydro-electric power from their two plants situated on the Mattagami river at Sandy and Wawaitin falls. Additional storage facilities are being provided at the head waters of the Grassy river, a tributary of the Mattagami, in order to provide an ample supply at low-water period, which usually extends from March until the spring break-up in April or May.

The prices of mine and mill supplies, which advanced considerably owing to war conditions, made the total costs higher than they otherwise would have been.

The total working costs at the Hollinger for the year, including depreciation, were $3.98 per ton, while at the Dome for the year ending 31st March, 1916, they were $2.56 per ton.

The Acme, which adjoins the Hollinger, was operated during 1915 by the Canadian Mining and Finance Company, Limited, the ore being treated in the Hollinger mill, but the returns kept separate. The McIntyre operated considerably from the Pearl Lake property which is under their control. The Schumacher carried on development work all year but did not begin to produce bullion until November. Favourable results were obtained in developing the North Thompson, but no mill has been erected as yet. The outlook at Porcupine for 1916 is undoubtedly good.

The production from the Province as a whole and from Procupine for the years 1910 to 1915 inclusive is shown in the following table:—

GOLD PRODUCTION, 1910-1915

Year.	Ontario.	Porcupine.
	$	$
1910	68,498	35,539
1911	42,637	15,437*
1912	2,114,086	1,730,628
1913	4,558,518	4,294,113
1914	5,529,767	5,190,794
1915	8,501,391	7,536,275

* The decrease in 1911 is due to the mills being burned in the great fire of that year.

Other Gold Areas:—Of the other gold mining areas, Kirkland lake is the most advanced, the Tough-Oakes being the largest producer outside of Porcupine. The new mill at the Tough-Oakes during 1915 treated 26,196 tons or ore yielding $551,069, or $21.04 per ton, out of which $132,875 was paid in dividends. The Lake Shore, Teck-Hughes, McKane and LaBelle Kirkland mines were engaged in development work in the same neighbourhood.

The Canadian Exploration Company at Long lake, near Sudbury, came next the Tough-Oakes in the value of gold produced.

The Dobie-Leyson claim in Munro township, now known as the Croesus mine, was one of the promising discoveries of the year. The quality of the ore from the shaft of this mine may be judged by the fact that from 800 pounds of quartz $40,000 in gold was recovered.

New Prospects:—Finds were also made at Boston creek. These are described by A. G. Burrows and P. E. Hopkins elsewhere in this report. At Kowkash, on the National Transcontinental railway, about 300 miles west of Cochrane, a spectacular showing was uncovered in the month of August by E. King Dodds. In the rush that followed, other veins were found in the vicinity, and also about 25 miles west, near Tashota. A preliminary report on the area by P. E. Hopkins accompanies this volume. Rich ore was also discovered south of Dryden near Contact bay, Wabigoon lake, on the Rognon claim.

The new finds will no doubt be developed in the near future. Meantime the year closed with an optimistic feeling in gold mining.

PRODUCING GOLD MINES, 1915.

Name of Company.	Name of Mine.	Locality.	P.O. Address of Manager, etc.
*Acme Gold Mines, Limited	Acme	Porcupine	Timmins.
Canadian Exploration Company, Limited	Long Lake	Long Lake	Naughton.
Cordova Mines, Limited	Cordova	Peterboro' county	Cordova.
Croesus Gold Mines, Limited	Croesus	Munro township	Matheson.
Dome Mines, Limited	Dome	Porcupine	South Porcupine.
Dome Lake Mining & Milling Company, Limited	Dome Lake	Porcupine	South Porcupine.
Gold Reef Gold Mines, Limited	Gold Reef	Porcupine	South Porcupine.
Hollinger Gold Mines, Limited	Hollinger	Porcupine	Timmins.
McIntyre-Porcupine Mines, Limited.	McIntyre	Porcupine	Schumacher.
Mines Leasing & Development Company, Limited	Rea	Porcupine	Schumacher.
Olympia Gold Mining Company, Limited	Olympia	Shoal Lake, Kenora district.	92 Reamy Street, St. Paul, Minn.
Porcupine Crown Mines, Limited	Porcupine Crown	Porcupine	Timmins.
Porcupine Pet Mining Company	Porcupine Pet	Porcupine	South Porcupine.
Porcupine Porphyry Hill Mining Company	Porphyry Hill	Porcupine	South Porcupine.
Porcupine Vipond Mines	Vipond	Porcupine	Timmins.
Schumacher Gold Mines	Schumacher	Porcupine	Schumacher.
Tough-Oakes Gold Mines, Limited	Tough-Oakes	Kirkland Lake	Kirkland Lake.

* Ore treated in Hollinger mill.

Silver

Ontario's silver production in 1915 was 24,823,660 ounces, worth $12,174,312, or nearly 12 per cent. of the total world production. The full production for 1915 was not marketed, several of the mines holding considerable silver in concentrates and bullion at the end of the year with the hope of obtaining higher prices. By

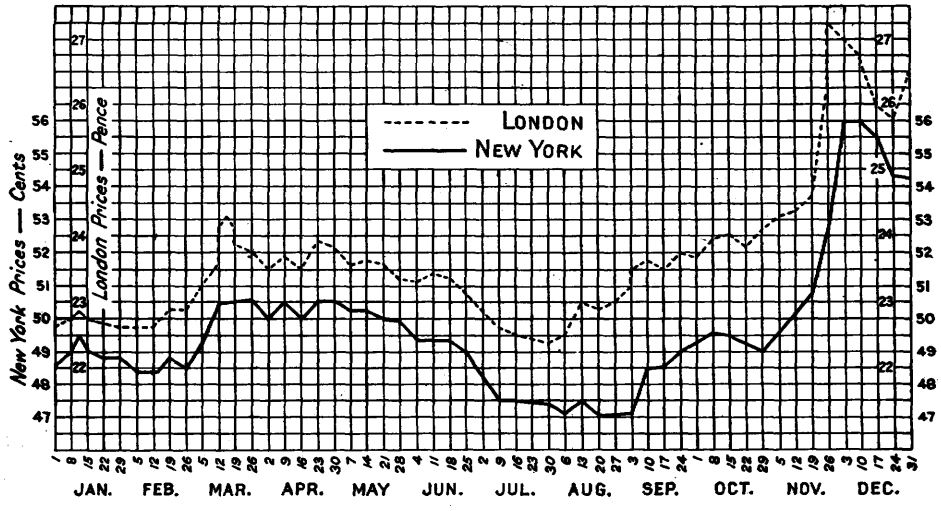


Diagram showing the weekly fluctuation of silver prices for 1915, as given by the Mining and Engineering World for New York and by Mocatta & Goldsmid for London. New York quotations are per fine ounce (Troy), while London prices are for bar silver, .925 fine.

reason of the continued low prices for the metal, the production, as compared with 1914, showed a decrease of 394,334 ounces. Development work was more expensive because of the increased cost of materials and labour as a result of the war.

In 1914 the average silver price was 54.81 cents, while in 1915 the average price fell to 49.684 cents per fine ounce. The lowest quotation for the year was 46¼ cents on September 1—the lowest known price for this metal. Toward the latter part of the year the demand for the metal for coinage purposes by belligerent countries caused a rise in price. There was also a considerable demand from India and China. The highest price for the year was 56¼ cents.

Apportioning the production to the several sources, we have the following:—

	Ounces.	Value. $
Cobalt	24,280,366	11,913,114
Casey township	223,939	105,846
Gowganda	242,229	116,856
Silver recovered from auriferous ores	77,126	38,496
Totals	24,823,660	12,174,312

Following the practice of former years, the mines shipping one-half million ounces or more of silver are given in the following list:—

Mine.	Ounces.
Nipissing	4,610,051
Mining Corporation of Canada (Townsite-City)	2,776,589
Kerr Lake	2,109,354
Seneca-Superior	1,996,257
Coniagas	1,916,616
Mining Corporation of Canada (Cobalt Lake)	1,566,206
Timiskaming	1,486,400
La Rose	1,071,694
McKinley-Darragh-Savage	1,061,827
O'Brien	991,084
Beaver Consolidated	970,168
Buffalo	839,010
Penn-Canadian	590,170
Crown Reserve	512,396
Cobalt Comet (Drummond)	507,367

Statistics of the yearly and total output of silver from the mines of Cobalt since their opening in 1904 are given in Table V, which follows:—

TABLE V.—SILVER PRODUCTION, COBALT MINES, 1904 TO 1915

Year.	Producing Mines.	Shipments and Silver Contents.					Av'ge Silver Contents per Ton.		Value of Silver Shipments.			Total.	
		Ore		Concentrates.		Bullion.	Ore.	Concentrates.	Ore.	Concentrates.	Bullion.	Ounces.	Value.
	No.	Tons	oz.	Tons.	oz.	oz.	oz.	oz.	$	$	$		$
1904	4	158	206,875	.....	.....	.....	1,309	.....	111,887	.....	.....	206,875	111,887
1905	16	2,144	2,451,356	.....	.....	.....	1,143	.....	1,360,503	.....	.....	2,451,356	1,360,503
1906	17	5,335	5,401,766	.....	.....	.....	1,013	.....	3,667,551	.....	.....	5,401,766	3,667,551
1907	28	14,788	10,023,311	.....	.....	.....	677	.....	6,155,391	.....	.....	10,023,311	6,155,391
1908	30	24,487	18,022,480	1,137	1,415,395	.....	736	1,244	8,468,293	665,085	.....	19,437,875	9,133,378
1909	31	27,729	32,436,355	2,948	3,461,470	.....	809	1,174	10,809,872	1,651,704	.....	25,897,825	12,461,576
1910	41	27,437	22,581,714	6,845	7,082,834	980,633	821	1,030	11,360,489	3,590,098	527,460	30,645,181	15,478,047
1911	34	17,278	20,318,626	9,375	8,056,189	3,132,976	1,176	858	10,250,991	4,017,241	1,686,615	31,507,791	15,953,847
1912	30	10,719	15,395,504	11,214	9,768,228	5,080,127	1,436	871	8,766,871	5,556,919	3,085,145	30,243,859	17,408,935
1913	35	9,861	13,668,079	11,016	8,489,321	7,524,575	1,386	770	7,444,995	4,554,797	4,554,189	29,681,975	16,553,981
1914	32	4,302	6,504,753	12,152	8,915,958	9,742,130	1,511	733	3,314,462	4,377,897	5,073,102	25,162,841	12,765,461
1915	24	2,865	6,758,286	11,996	10,001,548	7,986,700	2,359	834	3,422,627	4,673,624	4,039,565	24,746,534	12,135,816
Total	...	147,103	143,769,105	66,683	57,190,943	34,447,141	977	858	75,133,932	29,087,365	18,965,076	235,407,189	123,186,373

PRODUCING SILVER MINES, 1915

Name of Company or Owner.	Name of Mine.*	P.O. Address of Manager, etc.
Aladdin Cobalt Company, Limited	Chambers-Ferland	Cobalt.
Beaver Consolidated Mines, Limited	Beaver	Cobalt.
Buffalo Mines, Limited, The	Buffalo	Cobalt.
Casey Cobalt Silver Mining Company, Limited	Casey-Cobalt	New Liskeard.
Cobalt Comet Mines, Limited	Drummond	Giroux Lake.
Cobalt Silver Queen, Limited	Silver Queen	Cobalt.
Coniagas Mines, Limited, The	Coniagas	Cobalt.
Crown Reserve Mining Co., Limited	Crown Reserve	Cobalt.
Crown Reserve Mining Co., Limited	Drummond Fraction	Cobalt.
Crown Reserve Mining Co., Limited	Silver Leaf	Cobalt.
Kerr Lake Mining Company, Limited	Kerr Lake	Cobalt.
La Rose Mines, Limited	La Rose	Cobalt.
La Rose Mines, Limited	University	Cobalt.
McKinley-Darragh-Savage Mines of Cobalt, Limited	McKinley-Darragh-Savage	Cobalt.
Mining Corporation of Canada, Limited, The	Cobalt Lake	Cobalt.
	Townsite-City	Cobalt.
Nipissing Mining Company, Limited	Nipissing	Cobalt.
O'Brien, M. J.	O'Brien	Cobalt.
O'Brien, M. J.	Miller Lake-O'Brien	Gowganda.
Penn-Canadian Mines, Limited	Penn-Canadian	Cobalt.
Right of Way Mines, Limited, The	Right of Way	Cobalt.
Seneca-Superior Silver Mines, Limited	Seneca-Superior	Cobalt.
Temiskaming Mining Company, Limited	Temiskaming	Cobalt.
Trethewey Silver-Cobalt Mine, Limited	Trethewey	Cobalt.

Since the record year of 1911, when 31,507,791 ounces were produced there has been a steady decline in output. It is hoped that the flotation process of concentration will allow tailing dumps carrying only a few ounces of silver to the ton to be re-treated at a profit, thus prolonging the life and increasing the output of the Cobalt camp. Several of the producing companies are developing old prospects that have not received attention since the early days of Cobalt's history.

An interesting development is proceeding in the southeast section of the silver area, the expense of which is being borne jointly by the Timiskaming and Beaver mines. Diamond drilling has shown that the bottom of the diabase sill is about 1,700 feet below the surface. A shaft is being sunk to that depth in the hope that exploratory drifting near the lower contact will reveal productive veins similar to those found at or near the upper contact of the diabase and keewatin formations.

Other developments at Cobalt during the year included the complete dewatering of Kerr lake and the same undertaking initiated and completed at Cobalt lake, thus rendering accessible ore reserves assumed to exist between the beds of these lakes and the stope backs. In order to provide a new water supply for many of the mines and mills at Cobalt it was necessary to draw upon Brief, Short, Pickerel and Bass lakes in addition to the Montreal River. Pumping plants were erected at these points and a water supply service has been in continuous operation since April 29th, 1915. Up to the end of 1915 the total cost of dewatering Cobalt lake, including plant, was $10,704; and for the new water supply and lake drainage service the cost was $16,894. The work was undertaken and completed by the Mining Corporation of Canada.

*All the mines noted above are located at Cobalt, with the exception of the Casey Cobalt in Casey township and the Miller Lake-O'Brien at Gowganda.

Metallurgy.—In the metallurgical field doubtless the most important advance has been in the development of the flotation process and technical journals have given a great deal of attention to this subject throughout the year. As an auxiliary it would appear to fill a long felt want for the recovery of metals that slime-concentrating machines have attempted to gain heretofore. Some ores may be treated solely by flotation. It is particularly applicable to sulphide ores. The process will likely displace cyaniding to a large extent. There has been a great divergence of opinion as to the theory of the process but in practice the water, pulp and oil mixture is subjected to air agitation resulting in frothy oil rising to the surface and carrying with it metallic particles which are then skimmed. Unfortunately, litigation over patent rights has delayed the adoption of the process. In Ontario, an installation is proceeding at Massey for treating copper ore, and at Cobalt several of the mines, notably the McKinley-Darragh, Buffalo and Nipissing, are conducting experiments. It is contended that slimes carrying 5 or 6 ounces of silver can be profitably treated leaving only about one ounce unrecovered. If satisfactory results are obtained and the process generally adopted, it will mean considerable prolongation to the life of the Cobalt silver camp. Investigations are proceeding in the treatment of red pine stumps from Northern Ontario as a source of oil for use in the process.

Smelters and Refineries:—At Cobalt, silver bullion was produced by the Dominion Reduction Company, also by the Nipissing and Buffalo mines. The total bullion shipments for the year from Cobalt mines amounted to 7,986,700 ounces, valued at $4,039,565, or over 32 per cent. of the entire silver production of the Province.

Southern Ontario refineries operating in 1915 were the Coniagas Reduction Company at Thorold, the Metals Chemical Company at Welland, and the Deloro Mining and Reduction Company at Deloro. New items on the list of metallurgical products for 1915 from the silver-cobalt refineries are metallic nickel, cobalt and arsenic, also cobalt and nickel sulphates. The market for metallic cobalt has been somewhat limited although the suitability of the metal for electro-plating purposes has been amply demonstrated. There is, in addition, a certain field for its use in the manufacture of special steels. A suggested use of cobalt for coinage purposes, contained in Vol. XXIV, report of the Ontario Bureau of Mines, has met with favour in many quarters.

At the refineries there was produced and shipped metallic cobalt, cobalt oxide and cobalt sulphate. Metallic nickel was produced for the first time in addition to the regular output of arsenic nickel oxide and nickel sulphate. The total amount of silver-cobalt ore treated was 7,526 tons. Actual shipments from the refineries at Thorold, Welland and Deloro were as follows:—

—		Quantity.	Value.
Silver	ozs.	9,885,985	$4,942,993
Arsenic (white, grey and other forms)	lbs.	4,980,659	148,379
Cobalt (metallic)	"	111,558	103,746
Cobalt Oxide	"	314,906	254,447
Nickel Oxide	"	145,323	17,968
Nickel (metallic)	"	11,905	4,762
Nickel and Cobalt Sulphates, and Oxides not separated	"	75,447	9,227

Under the provisions of the Metal Refining Bounty Act (R.S.O. 1914, Chap. 33) a bounty of six cents per pound is paid on metallic cobalt and nickel and also on the metallic contents of cobalt and nickel oxides produced in the Province. It is stipulated in the Act that the maximum sum payable in any one year shall be $30,000 for cobalt and $60,000 for nickel. The bounty expires 10th April, 1917.

Bounties paid to the refiners of the Province on shipments for the year 1915 are shown in the following table:—

Company.	Cobalt Shipments.			Nickel Shipments.			Total Bounty.
	Pure Metal.	Cobalt oxide.	Bounty.	Pure Metal.	Nickel oxide.	Bounty.	
	lbs.	lbs.	$ c.	lbs.	lbs.	$ c.	$ c.
Coniagas Reduction Co., Limited	52,991	77,777	6,497 08	.....	126,359	5,058 59	11,555 67
Deloro Mining and Reduction Co., Limited.	54,383	196,130	10,967 28	11,163	300	682 74	11,650 02
Metals Chemical, Limited	.....	36,498	1,564 86	.....	18,267	780 36	2,345 22
Totals	107,374	310,405	19,029 22	11,163	144,926	6,521 69	25,550 91

The yearly and total production of silver, cobalt, nickel and arsenic from the ores of Cobalt since the mines were opened is as follows:—

TABLE VI.—TOTAL PRODUCTION, COBALT MINES, 1904 TO 1915

Year.	Nickel.		Cobalt.		Arsenic.		Silver.		Total Value.
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Ounces.	Value.	
		$		$		$		$	$
1904....	14	3,467	16	19,960	72	903	206,875	111,887	136,217
1905....	75	10,000	118	100,000	549	2,693	2,451,356	1,360,503	1,473,196
1906....	160	.....	321	80,704	1,440	15,858	5,401,766	3,667,551	3,764,113
1907....	370	1,174	739	104,426	2,958	40,104	10,023,311	6,155,391	6,301,095
1908....	612	.....	1,224	111,118	3,672	40,373	19,437,875	9,133,378	9,284,869
1909....	766	.....	1,533	94,965	4,294	61,039	25,897,825	12,461,576	12,617,580
1910....	504	.....	1,098	54,699	4,897	70,709	30,645,181	15,478,047	15,603,455
1911....	392	.....	852	170,890	3,806	74,609	31,507,791	15,953,847	16,199,346
1912....	429	14,220	934	314,381	4,166	80,546	30,243,859	17,408,935	17,818,082
1913....	377	13,326	821	420,386	3,663	64,146	29,681,975	16,553,981	17,051,839
1914....	(a) 90	28,978	(a) 351	590,406	2,030	116,624	25,162,841	12,765,461	13,501,469
1915....	(b) 35	28,353	(b) 206	383,261	2,490	148,379	24,746,534	12,135,816	12,695,809
Total.	3,825	99,518	8,213	2,445,196	34,037	715,983	235,407,189	123,186,373	126,447,070

(a) Metallic contents of nickel and cobalt oxides.
(b) Metals and metallic contents of all nickel and cobalt compounds.

Regarding the total production of cobalt, nickel and arsenic from the Cobalt camp, it is difficult to determine the actual quantities, because in the early days nearly all the ore was shipped abroad for treatment and the mine producers received little or no pay for these subsidiary constituents. The same still holds true for a small quantity of low grade ore shipped from the camp. Certain mines, however, sell at intervals cobalt residues which also contain nickel. A large pro-

portion of the arsenic, cobalt and nickel contained in the ore is now recovered by the southern Ontario refineries. Since 1910 and prior to 1914 it was assumed that the ores and concentrates shipped from Cobalt contained on the average 3.20 per cent. cobalt, 1.47 per cent. nickel and 14.28 per cent. arsenic, as explained in Volume XX, Part I, page 18. As pointed out in Part I of the 1914 Report, page 15, this basis of calculation is no longer applicable, and the total production of arsenic, cobalt and nickel is now based on the residues paid for and the actual recovery from Ontario refineries.

Copper

The monthly average price of electrolytic copper for the year 1915 was 17.275 cents per pound, an increase of 27 per cent. over the 1914 price, which was 13.602 cents. In December the price rose to 22 cents. The higher prices prevailing and the great demand stimulated development of copper properties that had been lying idle for some years. Apart from the copper contained in the nickel-copper matte produced at Copper Cliff and Coniston smelters, 271 tons of copper ore worth $4,418 was marketed. This was produced by the Sable River Copper Company, now operating the Massey mine. Other copper properties in the vicinity of Mine Centre, Rainy River district, were developed and shipments to British Columbia smelters started early in 1916.

The copper content of the nickel-copper ores treated at Sudbury smelters was 19,608 tons as compared with 14,448 tons produced in 1914.

Nickel-copper producers in 1915 were as follows:—

NICKEL-COPPER PRODUCERS, 1915

Name of Company.	Name of Mine.	Location.	P.O. Address of Manager, etc.
Canadian Copper Company.....	Creighton,Crean Hill,No.2, etc.	Sudbury.....	Copper Cliff
Mond Nickel Company, Limited	Victoria, Garson, etc.....	"	Coniston
E. F. Pullen.....	Alexo	Dundonald tp ..	Porquis Junc.
Sudbury Leasing and Development Co.....	Mount Nickel	Sudbury.....	Sudbury

A record of nickel-copper mining and smelting operations for the past five years is shown in the following table:—

TABLE No. VII.—NICKEL-COPPER MINING, 1910 TO 1915

Schedule.	1911	1912	1913	1914	1915
Ore raised ..... tons	612,511	737,656	784,697	1,000,364	1,339,322
Ore smelted..... "	610,788	725,065	823,403	947,053	1,272,283
Bessemer matte produced..... "	32,607	41,925	47,150	46,396	67,703
Nickel contents..... "	17,049	22,421	24,838	22,759	34,039
Copper contents ..... "	8,966	11,116	12,938	14,448	19,608
Value of Nickel..... $	3,664,474	4,722,040	5,237,477	5,108,997	17,019,500
Value of Copper ..... $	1,281,118	1,581,062	1,839,438	2,080,034	3,921,600
Wages paid ..... $	1,830,526	2,357,889	3,291,956	3,131,520	3,581,639
Men employed..... No.	2,439	2,850	3,512	3,464	4,178

Nickel

The production of this metal in 1915 was much greater than in any previous year in the history of nickel mining in Ontario. Of nickel-copper matte the output from the Copper Cliff and Coniston smelters was 67,703 tons, as compared with 47,150 tons in 1913, and 46,396 tons in 1914. In 1913 and 1914 the nickel content of the matte produced was 24,838 and 22,159 tons respectively, while in 1915 the quantity was 34,039 tons, making the total production of nickel from the Sudbury region 237,204¼ tons up to the end of 1915. So unprecedented an increase in the production of nickel, owing to the higher prices prevailing and the unusual demand for nickel-steel for armament and munition purposes, is a direct outcome of the great war now raging.

In addition to the nickel from the Sudbury ores, there was produced within the Province, for the first time, metallic nickel obtained by the refining of cobalt-nickel arsenides from Cobalt, Ontario. This metallic nickel, amounting to 11,905 lbs., was produced by the Deloro Smelting and Refining Company at Deloro, Ontario.

During the year the quantity of nickel-copper ore raised was 1,339,322 tons, of which 11,923 tons came from the Alexo mine in Dundonald township, and 13,348 tons from the Mount Nickel mine operated by the Sudbury Leasing and Development Company. Ore smelted by the Canadian Copper Company at Copper Cliff and the Mond Nickel Company at Coniston amounted to 865,169 and 407,144 tons respectively. The production of the different mines is shown in the following table:—

TABLE VIII.—NICKEL-COPPER ORE RAISED IN 1915

Canadian Copper Co.		Mond Nickel Co.	
Mine.	Tons (2,000 lbs.)	Mine.	Tons (2,000 lbs.)
Creighton	778,976	Garson	193,562
Creen Hill	104,550	Kirkwood	38,448
No. 2	55,923	Victoria No. 1	58,248
Vermilion	889	Worthington	49,739
		Levack	31,755
Total	940,338	Bruce	1,961
			373,713
		*Alexo	11,923
		*Mount Nickel	13,348
*Ore purchased by the Mond Nickel Co., and treated at Coniston smelter.		Total	398,984

Iron Ore

The production in 1915 came from the same three mines as in 1914. Of the 394,054 tons of iron ore shipped 88,322 tons went to the United States and 305,732 tons to Ontario blast furnaces. The total valuation was $764,515 or $1.94 per ton. In Table I—Mineral Statistics for 1915—the value of exported

ore only is given as the remainder went to Ontario smelters for pig iron manufacture and its accrued value is given under that heading.

During the year 392 men were employed at the mines, and wages amounted to $224,306.

The following is a list of companies operating in 1915:—

IRON MINING COMPANIES, 1915

Name of Company.	Name of Mine.	Location.	P.O. Address of Manager, etc.
Algoma Steel Corporation, Limited.....	Helen	Michipicoten ..	Helen Mine.
	Magpie.....	Michipicoten ..	Magpie Mine.
Moose Mountain, Limited.....	Moose Mountain	Sudbury dist ..	Sellwood.

Pig Iron and Steel

During 1915 Ontario blast furnaces smelted 916,399 tons of iron ore, of which only 293,305 tons or 32 per cent. was of domestic production. The Canadian Furnace Company used imported ores entirely. The other iron and steel plants smelted some Ontario ore, the largest consumer being the Algoma Steel Corporation, which used domestic ore to the extent of 63 per cent. of the entire amount smelted. Scale and mill cinder produced amounted to 13,720 tons. Employees, in blast furnaces only, numbered 563.

The total pig iron product was 493,400 tons valued at $5,910,625. Crediting 32 per cent. to Ontario ores, the resulting figures are 157,888 tons worth $1,891,400. Heretofore the entire output of pig iron has been included in Table I showing the total valuation of the mineral production of the Province.

Early in the year the iron and steel industry recovered from the period of depression following the outbreak of war, and prices rose abnormally as a result of the great demand for iron and steel in the manufacture of munitions. Of the total pig iron production 329,974 tons were used in making steel.

The following figures summarize the details of the iron and steel-making industry for a five-year period:—

TABLE IX.—PRODUCTION IRON AND STEEL, 1911 TO 1915

Schedule.	1911	1912	1913	1914	1915
Ontario ore smelted.....tons	67,631	71,589	132,708	163,779	293,305
Foreign ore smelted..... "	848,814	1,062,071	1,095,561	752,560	623,094
Limestone for flux..... "	275,628	305,509	351,741	252,258	215,686
Coke ..... "	577,388	660,248	706,852	590,902	486,022
Charcoal .....bush	1,666,897	1,886,748	2,206,191	920,045	1,314,957
Pig iron .....tons	526,610	589,593	648,899	556,112	493,400
Value of pig iron..... $	7,716,314	8,054,369	8,719,892	7,041,079	5,910,625
Steel .....tons	361,581	457,817	648,948	479,320	471,059
Value of steel..... $	9,505,013	8,071,339	11,230,109	7,786,303	7,618,272

The following companies were producers of pig iron in 1915:—

MAKERS OF PIG IRON, 1915

Name of Company.	No. of Furnaces.	Fuel used.	Location.
Algoma Steel Corporation	3	Coke	Sault Ste. Marie.
Canadian Furnace Co	1	"	Port Colborne.
Standard Iron Co	1	Charcoal	Deseronto.
Steel Company of Canada	2	Coke	Hamilton.

Molybdenite

Molybdenite (MoS_2), a sulphide containing 60 per cent. molybdenum, occurs in thin, bright, non-elastic, lead-coloured flakes, which are easily scratched by the finger nail and bend readily. It is more commonly found in irregular lumps, easily cleavable into thin leaves. When molybdenite contains no mica or other substance harmful to steel and difficult to separate, it is most valuable. In the last report, Vol. XXIV, Part I, pages 52-54, reference is made to the sources and uses of molybdenum. The only production of molybdenite in Ontario, prior to 1915, was confined to the years 1901 and 1902, when ore valued at $1,675 was marketed.

The great demand for molybdenum, incident to the war, is due to the difficulty in securing sufficient tungsten for the hardening of tool steel. Molybdenum serves the same purpose. The Imperial Munitions Board, Ottawa, is in charge of procuring supplies from Canada for the British Government.

Molybdenite in 1915 was shipped in the form of ore and concentrates, the latter containing 85 per cent. or more of MoS_2. Ore shipments amounted to 192 tons valued at $12,859. Concentrates amounted to 1,068 pounds, worth $1,240. Concentrating was done by the Orillia Molybdenum Company at Orillia, and by the Ore Dressing and Metallurgical Division of the Mines Branch, Ottawa. The following is a list of the producers of molybdenite:

MOLYBDENITE PRODUCERS, 1915

Name	Location of Deposit.	P. O. Address.
Chisholm, A. M.	Sheffield tp.	Enterprise.
Jamieson Syndicate (J. F. McKenzie, Manager)	Lyndoch tp.	Orillia.
McMahon, Frank	Cardiff tp.	Toronto.
O'Brien, M. J.	Mount St. Patrick	Renfrew.
Orr, F. O.	Cardiff tp.	Peterboro.
Paterson, M. J. and Pellatt, Henry	Bagot tp.	Toronto.
Spain, W. J.	Dacre	417 Fifth Ave., New York.
Russell, A. J. H. and Ponton, Douglas	Norland	Toronto.

Ontario molybdenite deposits are widely distributed, as will be seen from the investigations by A. L. Parsons, of the University of Toronto. His report, appended herewith, is preliminary to a fuller one which will appear in the Twenty-sixth Report:—

During the month of May and part of the month of June, 1916, the writer was engaged in an examination of the occurrences of molybdenite in eastern Ontario with a view to ascertaining not only the mode of occurrence but also the possibilities of production of this mineral which is in considerable demand at the present time for the manufacture of high-speed steel. In the present state of the industry it is difficult to accurately judge the possibilities of old prospects or even new ones upon which only a little work has been done, as most of the high-grade molybdenite has been removed from the older prospects and the remaining material has been oxidized and to a large extent washed away, while in the newer prospects it is seldom that fresh molybdenite shows on the surface, and it is necessary to estimate the quantity of rock that has been removed and then estimate the proportion of high-grade ore that has been laid to one side. In either case the results are likely to be fallacious, with the probability of minimizing the quantity of molybdenite present.

In view of the demand for molybdenite for munition work, this preliminary report is submitted before the completion of the work so that those interested in the development of the industry may have a list of the known occurrences to guide them in their search for properties and also that the prospector may have the common association well in mind.

With but few apparent exceptions to the rule, the molybdenite of eastern Ontario is intimately associated with pegmatite dikes in the gneisses and crystalline limestone, probably of Grenville age. In case limestone is present it is usual to find that the pegmatite is not directly in contact with the limestone but is separated from it by a band of pyroxenite which is presumably due to a chemical reaction between the pegmatite and the limestone. Where this pyroxenite is present it usually carries the greater part of the molybdenite and with it considerable quantities of pyrite and pyrrhotite. In certain instances brown and black mica replace part of the pyroxene. When limestone is absent and the pegmatite has intruded gneissic rocks the pyroxenite band is seldom present and the molybdenite is in the normal pegmatite, but in only one case did the writer find an outcrop where no trace of pyroxene was to be seen. In the more normal pegmatite deposits tourmaline is frequently associated with the molybdenite, and in certain instances the pegmatite becomes more siliceous until it appears to be an ordinary quartz vein. The deposits at Net Lake, near Timagami, district of Nipissing, appear to be an exception to the pegmatitic origin of the deposits. At this place the molybdenite is present in a series of gash veins of quartz, which contain in addition small quantities of gold and copper, the latter being in the form of chalcopyrite. Whether these veins are pegmatitic in origin is not definitely known, though such an origin has been suggested for some of the gold veins at Porcupine.* In case the pegmatitic origin for this deposit can be shown, the deposits of eastern Ontario may all be grouped together as being associated with pegmatite.

A list of localities where molybdenite has been found in Ontario is given below and brief comments are made concerning the development of some of them.

ADDINGTON COUNTY

Sheffield township.—Lot 5, con. XIV. Chisholm mine. About a dozen men were working in clearing the pits and in regular mining work. The old stock piles were being cobbed and the high-grade ore shipped. The mine is being operated by the International Molybdenum Company, Limited.

Lot .., con. ... On the farm of Timothy Dwyer is a pit about 8 x 10 feet and 10 feet deep, at which some molybdenite was seen. Not working.

Lot 8, con. XV. On the farm of Matthew Spratt a pit about 10 x 20 feet and more than 10 feet deep was sunk in pegmatite by L. L. Cailloux. The bottom of the pit was filled with water.

Lot 12, con. XII. On the farm of A. Kellár five open cuts have been opened up by O'Briens-Greenfield, of Superior, Wisconsin, and about 160 pounds of pure flake have been taken out in the prospecting. Five men were working at the time of the writer's visit.

Lot 15, con. XVI. Owner, Wm. Wager. Property not visited.

VICTORIA COUNTY

Laxton township.—Lot 5, con. XI. Two mines are being developed at this place, one on the farm of Wm. Adair by T. Horscroft; the other a few feet away in Mud Turtle lake by Douglas Ponton and A. J. H. Russell. At the time of the writer's visit, Mr. Horscroft was just installing a pump and had done very little work, but the writer was later informed that he had taken out ore which was being shipped to the Mines Branch, Ottawa. Little could be seen of the association, but a small pegmatite dike shows up and a few flakes of molybdenite were found in pyroxenite above water level in the pit which had been opened. The other property, under the management of Captain Russell, was not working on account of the high water which had flooded the shaft. This shaft is about 50 feet deep, and encounters a micaceous pyroxenite containing considerable molybdenite. Several tons of concentrating ore were in a stock pile.

*Report Ont. Bur. Mines, Vol. XXIV, Part 3, pp. 28-30.

Lutterworth township.—Lot 7, con. X. On property belonging to A. Y. Hopkins, of Kinmount, a small opening has been made in a small quartz vein in gneiss. Some molybdenite has been found, but probably this vein is not economic. There is, however, a larger mass of pegmatite a few rods to the west which might pay for further prospecting.

RENFREW COUNTY

Hagot township.—Lot 15, con. X. Owner, Samuel Hunter, Calabogie. No work has been done for some years and the deposit does not appear to be economic.

Lot 28, con. XII. On the farm of John Culhane, Ashdod, development work has been done by R. R. Gamey. The molybdenite occurs in a pyroxenite mass adjoining pegmatite. Mr. Culhane informed the writer that about 200 pounds of pure flake had been taken out. There is about a half ton of concentrating ore on the dump. The pit is about 40 feet long by 8 feet wide and averages 4 feet in depth.

Lot 27, con. IV. On the farm of Wm. Warren development work has been done by Mark J. Paterson and Sir Henry Pellatt. The pits were filled with water and the molybdenite-bearing rock was not seen in places. Several tons of low grade ore were seen on the dump.

Lot 25, con. IV. On the farm of Mr. Morin of Springtown. Property not examined.

Brougham township.—Lots 35 and 36, con. XIV. An open cut about 10 x 70 feet has been excavated by Legree Bros., Dacre, in a micaceous pyroxenite. About 8 tons of ore running possibly 3 per cent. MoS_2, together with possibly 400 pounds of pure flake, had been taken out and laid aside for shipment. The property merits further prospecting, and the ore should be shipped to prevent loss by oxidation.

Lots 16 and 17, con. XI, and lot 17, con. X. Owners of mineral rights, International Molybdenum Company, Limited. Development work is being carried on under the superintendence of J. C. Murray. From 20 to 30 men are employed. The molybdenite is in a series of parallel pegmatite-pyroxenite dikes, and at the time of the writer's visit the work had all been by stripping and open cuts. More than 200 tons of concentrating ore have been shipped from this property. The writer was informed that a shaft was started after his visit.

Lots 7, 8 and 9, con. XI, and lot 8, con. XII. The Renfrew Molybdenum Mines, Limited, under the superintendence of Charles Spearman, are working on a low-grade pyroxenite which lies between Grenville limestone and pegmatite. Several carloads of concentrating ore have been shipped from the property. A drift about 60 feet long and a cross cut about 90 feet in length have been driven into this deposit and two holes have been put in with a core drill. The deposit as exposed is about 600 feet long and 40 feet wide, and apparently offers a large tonnage of concentrating ore. Preparations were in progress for the erection of a mill, and two boilers were being installed. It is proposed to use the Elmore (flotation) concentrator in the mill. Preparations were being made for the sinking of a shaft.

Lot 15, con. XI, known as the Connelly-Chown property. Two pits have been sunk on a couple of narrow pegmatite dikes of apparently the same character as those on the adjoining claims, which are worked by Mr. Murray.

Bromley township.—Lot 24, con. V. Lessee, J. E. Cole, Renfrew. Development work is being done on a large mass of pyroxenite and about a ton and a half of concentrating ore has been shipped.

Blithfield township.—Lot 29, con. I. Some development is reported on the farm of Thomas Quilty, but the property was not seen by the writer. He was informed, however, that further development work will be done during the summer.

Griffith township.—Lots 31 and 32, con. V, and lot 31, con. IV. Owner, W. J. Spain, New York city. Manager, George R. Gray, Dacre. The molybdenite is in two dikes of pegmatite and pyroxenite in gneiss and crystalline limestone separated by about 10 feet of gneiss. The two dikes together give a width of about 25 feet of working ore. The molybdenite occurs in extremely large flakes, some of them being more than a foot across. Masses of nearly pure molybdenite weighing as much as 50 pounds have been taken out. A mill has been erected and was nearly ready for work. As much of the flake molybdenite as possible will be picked out on picking belts, and the remainder, after passing through rolls, will go to a Hooper Pneumatic Concentrator.

Lyndoch township.—Lots 5 and 6, con. VII. Jamieson mine, operated by the International Molybdenum Company, Limited. Idle at the time of the writer's visit and workings filled with water. There were 57 sacks of low-grade ore ready for shipment and a few small piles of ore to be cobbed. This is looked upon as one of the promising properties.

Matawatchan township.—Lot 3, con. VI. On the farm of James Wilson one shot has been put in a pyroxenite mass. Mr. Wilson's son told the writer that 2½ pounds of pure

molybdenite had been taken out. The rock that had been blasted out appeared to have run about ⅓ to ½ per cent., and showed flakes of molybdenite scattered through it. The pyroxenite is on the margin of a large pegmatite mass and is from 40 to 50 feet wide. Nothing definite can be said as to values at present, but there is a possibility of a large tonnage of low-grade material. Further prospecting is desirable.

Miller township.—Lot 3, con. —. On the farm of Thomas Armstrong a pegmatite dike has been opened up by C. G. Shannon, of Kingston. Some molybdenite was seen, but the property does not appear to be high grade.

Lot 3, con. 8. Property not visited.

Lot 5, Northeast Range. Not visited.

Raglan township.—Lot 27, con. IX, and lot 27, con. X. Three pits have been sunk on these properties and molybdenite is on two of the dumps. The best pit is on or near the line between the two properties. The dike is about 4 feet wide, and 30 to 40 tons of rock have been removed, and possibly a ton of 3 per cent. ore lies on the dump. The other two pits are on concession IX. John Windle owns the lot in concession X and H. Liedke the lot on concession IX.

Ross township.—Lot 22, con. II. Owner, John Rose, Haley. An open cut has been made in a pegmatite dike from 2 to 4 feet wide. The cut is about 50 feet long and from 2 to 8 feet wide. The part showing molybdenite was under water. A ton or so of concentrating ore was on the dump.

Lot 7, con. IX. Property not visited, but the writer was informed that no work had been done for several years.

Sebastopol township.—Lot 18, con. VII. On the farm of Edward Ziebarth are two small dikes in gneiss and crystalline limestone. Some molybdenite has been found, but further development is necessary to show a sufficient quantity for commercial purposes.

HALIBURTON COUNTY

Cardiff township.—Lot 12, con. XI. Owners of mineral rights, Matthews and McMahon. An opening from which possibly 50 tons of rock has been taken has been made in pegmatite. Some large flake has been taken from this place and a small amount of concentrating ore is on the dump. No estimate could be made as to values.

Lot 11, con. X. On the farm of Alex. Evans a shaft has been sunk and an open cut has been made, but the property has not been worked for some time and the workings are filled with water. A small concentrating plant was erected containing a Wettlaufer crusher, 12-inch rolls and a screen. Several tons of finely pulverized ore containing small flakes of molybdenite were stored in a bin.

Lot 18, con. IX. On the farm of John Mooney is a mass of pegmatite, in which scales of molybdenite are visible. No work has been done on the outcrop.

Lot 6, con. IX. Owner, Walter R. Kidd, Paudash. An open cut has been made upon two parallel pegmatite dikes, each about a foot wide, in gneiss.

Lot 11, con. V. Owner, Walter R. Kidd, Paudash. Two open cuts or pits have been made upon a deposit similar to the last mentioned.

Harcourt township.—Lot 3, con. I and II. This is the property formerly worked by S. Dillon Mills and described by him.* In the main workings little molybdenite was to be seen, but at one of the workings further south a considerable quantity of rich ore had been laid to one side. This ore is a concentrating ore, but the writer would judge that there is from one to two tons of 15 per cent. ore at this place.

GENERAL.

Other localities which have been mentioned in various reports are noted below, but in most instances the deposits are probably not of economic importance.

Anstruther township, lots 24 and 25, con. XIV.

Beatty township, lot 4, con. I.

Belmont township, not far from Cordova mines.

Big Duck lake, north of Schreiber.

Black river, Lake Superior region. (Probably the same as Terrace Cove.)

Carlow township.

Craigmont, Raglan township.

Digby township, lot 16, con. VII.

Dungannon township, lot 25, cons. XIII and XIV. Visited, but no molybdenite was found.

* Report Ont. Bur. Mines, Vol. XI, p. 45.

Foley township, lots 32 and 33, con. V.

Graham township.

Gull lake, northeast from Dryden. Not visited. The writer was shown good flakes of molybdenite from this locality several years ago.

Kirkland lake, district of Timiskaming.

Lake of the Woods region. Several occurrences are known and have been visited by the writer, but with possibly one exception they are not economic.

March township, lot 6, con. II. Not visited.

Molybdenite lake near Michipicoten Harbour.

Monteagle township, lots 26 and 27, con. VI. Visited, but no molybdenite found. It is also reported from lot 6, con. I.

North Crosby township, lot 14, con. V.

Bear's Passage, Rainy lake.

Smooth Rock lake, Manitou region. Not economic.

Somerville township, lot 3, con. A. Visited. No molybdenite was found. This was the second locality at which molybdenite was discovered in Canada.

Swastika, district of Timiskaming.

Talon Chute, about 25 miles east of North Bay. Dr. T. L. Walker reports that he fonud graphite but not molybdenite.

Terrace Cove, Lake Superior. This was the first locality at which molybdenite was discovered in Canada.

Worthington mine, Sudbury district. Not economic for molybdenite.

CONSTRUCTION MATERIALS

Nowhere was the depression in business resulting from the war more keenly felt in 1915 than by the producers of materials used in the building trades. The production for 1914 was not greatly affected, but during 1915 building operations were almost at a standstill. This condition is reflected in brick and tile production which fell to about one-third that of 1914. Lime, stone and cement production fell off, but by lesser quantities. In the city of Toronto building permits which had advanced rapidly between 1909 and 1913 from $18,139,247 to $27,401,761, decreased in 1914 to $20,694,288, and to $6,659,383 in 1915. The end of the year, however, saw a general revival in business and 1916 opened with optimism.

Brick, Tile, Sewer Pipe and Pottery

Of the brick and tile works in Ontario about 30 per cent. were idle in 1915, while, in most cases, the output of the others was materially reduced. The average valuation of common brick was $7.96 and of pressed brick $8.75 per thousand, as compared with $7.99 and $10.66 in 1914.

The following table shows the comparative value in dollars of the 1914 and 1915 production:—

Year.	Brick.			Pottery.	Drain tile.	Sewer pipe.	Total.
	Common. $	Pressed. $	Fancy, Terra Cotta, etc. $	$	$	$	$
1914..	2,336,207	656,944	237,440	25,720	277,530	571,756	4,105,597
1915..	763,591	217,350	158,515	49,387	321,253	361,283	1,871,379

As regards the raw material used in common brick manufacture the following table shows the kinds employed:—

	Clay.	Shale.	Sand-Lime.	Cement.	Total.
No. of Brick—M.....	85,976	2,450	3,360	181	91,967
Value $.....	686,832	51,026	22,840	2,893	763,591

LABOUR AND FUEL COSTS.

Year.	Workmen employed.		Wood.	Coal and Coke.	Natural Gas.	Fuel Value.
	No.	Wages. $	Cords.	Tons.	M. cu. ft.	$
1914.....	2,523	978,498	65,079	67,226	140,835	576,334
1915.....	1,627	445,726	31,994	34,656	297,288	265,007

The above table applies only to common brick and tile works. Cheap fuel is vital to economical production. Wood alone was used in 61 plants, coal or coke in 14, and natural gas in 21. Some 43 operators used coal or coke in addition to wood.

Although some of the larger brickyards operate practically the year round, the season for the small plants is a short one. The average run in 1915 was 109 days.

Following is a list of the brick and tile manufacturers reporting to the Bureau:—

BRICK AND TILE-MAKING PLANTS.

Name.	Address.	Product.
Allen, Solomon	Brantford	Brick.
*Alsip, George	Fort William	Brick and Tile.
Alvinston Brick & Tile Co., Limited	Alvinston	Brick and Tile.
Armstrong Bros.	Fletcher	Tile.
*Armstrong, Geo. H.	Brigden	Hollow Blocks and Tile.
Arnold, Willard	Virginia	Brick.
Arnott, Thos. H.	Bracebridge	Brick.
*Ashbridge Brick Co.	Toronto	Brick.
*Baeckler, William	Chesley	Brick.
Baird & Son, H. C.	Parkhill	Brick and Tile.
Baker, Geo. E.	Arnprior	Brick and Tile.
*Baker Bros.	Casselman	Brick and Tile.
Bartonville Pressed Brick Co., Ltd.	Bartonville	Pressed Brick.
Beckett, E. C.	Orwell	Brick and Tile.
Bell Bros.	Paisley	Brick and Tile.
Bell Bros. & Co.	Toronto	Brick.
Bemrose, Thos.	Beeton	Brick.
*Blake, Elias D.	Lucan, R.R. No. 2	Brick and Tile.
Bogart Bros.	Southwold	Brick and Tile.
Bond & Bird	Woodstock	Brick.
Boone, Geo. H.	Thornbury	Brick.
Bowler, C. W.	Markdale	Brick.
Brampton Pressed Brick Co., Ltd.	Brampton	Pressed Brick.
Brandon Pressed Brick & Tile Co., Limited	Milton	Pressed Brick.
*Brantford Brick Co., Limited	Brantford	Brick.
Broadwell, Benj.	Kingsville	Brick and Tile.
Brown, J. W.	Vienna	Brick and Tile.
*Brown Bros. Brick Co.	West Toronto	Brick.
Brownscombe & Sons, H.	Cargill	Brick and Tile.
Brownscombe, E. N.	Paisley, R.R. No. 2	Brick and Tile.
Buchanan Bros. & Co.	Thessalon	Brick.
Buck, J. L.	Port Rowan	Brick and Tile.
*Bushell, Wm.	Toronto	Brick.
Butwell Brick Co.	Toronto	Brick.
Cabana, Jr., Oliver	Zurich	Brick and Tile.
Campbell, Neil F.	West Lorne	Brick and Tile.
Card, N. B.	Harrisburg	Brick and Tile.
Canadian Pressed Brick Co., Limited	Hamilton	Pressed Brick.
Clemens, Moses	Thamesville	Brick and Tile.
Consolidated Brick and Tile Co.	West Toronto	Brick and Tile.
Cooper, W. H.	Hamilton	Brick.
Cornhill Sons, Ltd.	Chatham	Brick.
*Crawford Bros.	Hamilton	Brick.
*Credit Forks Tile & Brick Co., Ltd.	Toronto	Brick and Tile.
*Crowhurst, W. J.	Port Hope	Brick.
Cumberland, J. M.	Listowel	Tile.
Curtis Bros.	Peterboro'	Brick and Tile.

*Not working in 1915.

Name.	Address.	Product.
*Davenport, B. F.	Orwell	Brick and Tile.
Deller & Sons, Geo.	Norwich	Brick and Tile.
*Deller, Wm. H.	Thorndale	Tile.
*Dominion Brick & Tile Co., Ltd.	Breslau	Brick.
Dominion Sewer Pipe Co., Limited	Waterdown	Brick.
Donaldson Bros.	Harriston, R.R. No. 4	Brick.
Don Valley Brick Works	Todmorden	Common, Pressed and Fancy Brick, Porous Hollow Blocks, etc.
Dublin Brick & Tile Works	Dublin	Brick and Tile.
Elliott, William	Glenannan	Brick and Tile.
*Emard, Trefflé	Embrun	Brick.
Forman, Stephen	St. Marys	Tile.
*Fort William Brick & Tile Co.	Fort William	Brick and Tile.
Fox, G. J.	Dresden	Brick.
Frank, E. D.	Strathroy	Brick.
Fraser, Chas.	Blyth	Brick and Tile.
Freek, William	Barrie	Brick.
Frid Brick Co., Ltd., Geo.	Hamilton	Brick.
Frid Bros.	Hamilton	Brick.
Frost, Geo. H.	Toronto	Brick.
Fuller, Geo.	Belwood, R.R. No. 2	Brick and Tile.
Gardiner, William	Blenheim	Brick and Tile.
George & Sons, Mrs. E. D.	Mossley, R.R. No. 2	Brick and Tile.
Govenlock, J. M.	Seaforth, R.R. No. 1	Brick and Tile.
*Gowanlock, J.	West Fort William	Brick.
Hall Estate, Ellen	Cobourg	Brick and Tile.
Hallatt, H.	Comber	Brick and Tile.
*Hallman, J. B.	Hanover	Brick.
Hamilton Pressed Brick Co., Limited	Hamilton	Pressed Brick.
Hamley, R. H.	Bowmanville	Brick and Tile.
Hancock, William	Hamilton	Brick.
*Harbour Brick Co., Limited	Toronto	Sand-Lime Brick.
Hepworth Silica Pressed Brick Co., Ltd.	Hepworth	Pressed Brick.
Hill, Will J. & James S.	Madoc	Brick and Tile.
Hill Bros.	Essex	Brick and Tile.
Hill Bros.	Coatsworth, R.R. No. 1	Brick and Tile.
*Hill, Sanford	Parkhill	Tile.
Hinde Bros.	West Toronto	Brick.
Hiscock & Sons	Cobourg	Brick.
Hitch, Mrs. Susan	Ridgetown	Brick and Tile.
Hitch, Thos.	St. Thomas	Brick and Tile.
Hohl, Geo.	Lisbon	Brick and Tile.
Holton, Fred. E.	Clifford, R.R. No. 3	Brick.
Holton, R. J.	Clifford, R.R. No. 3	Tile.
Howlett, Fred.	Petrolia	Brick and Tile.
Interprovincial Brick Co. of Canada, Limited	Cheltenham	Pressed and Fancy Brick.
Jamieson, J. A.	Renfrew	Brick and Tile.
Janes, D. A.	Delaware	Brick and Tile.
Jasperson, B.	Kingsville	Brick, Tile, Cement Blocks.
Jervis & Son, John	Dorchester Station	Brick and Tile.
Johnson, James	Pembroke, R.R. No. 3	Brick.
Jordan, D.	Chatham	Brick and Tile.
Kaar, John	Brownsville	Brick and Tile.
Kingston Brick & Tile Co., Limited	Kingston	Brick and Tile.
Koebel, Joseph Z.	St. Clements	Brick and Tile.
Kruse Bros.	Egmondville	Brick and Tile.
Kuhn, Henry J.	Crediton East	Tile.

*Not working in 1915.

Name.	Address.	Product.
*Lang Bros.	Merrickville	Brick.
*Launders, Thos.	Fruitland	Brick.
Leamington Brick & Tile Co., Ltd.	Leamington	Brick and Tile.
Leatherdale, R. W.	Dresden	Tile.
Lethbridge Brick Co., Limited	Steelton	Brick.
Light, William	Aylmer	Brick and Tile.
Lindsay, Stephen	Wallaceburg, R.R. No. 2.	Tile.
Lingham, W. T.	Belleville	Brick.
Logan, John	Toronto	Brick.
Lowes, Gordon	Kent Centre	Brick and Tile.
MacKay Bros.	Dutton	Brick and Tile.
McCormick Bros.	Kingscourt	Brick and Tile.
McCredie & Reid	Lyons	Brick and Tile.
McGibbon, Dugald	Shedden	Tile.
McLoughlin, John	London	Brick.
Maloney, John	Humber Bay	Brick.
Mann Brick Co., Limited, John	Brantford	Sand-Lime Brick.
Marshall, W. W.	Woodstock	Brick and Tile.
Martin, David	Thamesville	Tile.
Martyn, W. A.	North Bay	Brick.
Mason, Charles	Toronto	Brick.
Meaford Brick Co., Limited	Meaford	Brick.
*Merkley Bros., Limited	Casselman	Brick.
Mills, Geo. E.	Hamilton	Brick.
Milton Pressed Brick Co., Limited	Milton	Pressed and Fancy Brick.
Miner, J. T.	Kingsville	Brick and Tile.
*Morley, Walker	Toronto	Brick.
*Morley & Ashbridge	Toronto	Brick.
Munro, D. W.	Carp	Brick and Tile.
Napanee Brick & Tile Co., Limited (A. F. Clark, lessee)	Napanee	Brick.
National Fire Proofing Co. of Canada, Limited	Aldershot	Terra Cotta, Hollow Blocks.
Nayler & Sons, J. W.	Trenton	Brick.
New, Edward	Hamilton	Brick.
Norton, Alsey	Bolton	Brick and Tile.
Norton, David	Woodbridge	Cement Tile.
Norton, T. W.	West Toronto	Brick.
*Oakville Pressed Brick Co.	Oakville	Brick and Tile.
Odell & Sons, Wm.	Ingersoll	Brick and Tile.
*Ollmann Bros.	Hamilton	Brick.
*Ontario National Brick Co., Limited	Cooksville	Brick.
*Ontario Paving Brick Co., Limited	West Toronto	Paving Brick and Blocks.
O'Reilly, T. E.	Ottawa	Brick.
Ott Brick & Tile Mfg. Co., Limited	Kitchener	Brick.
Ottawa Brick Mfg. Co., Limited	Ottawa	Brick.
Owen Sound Brick Co., Limited	Owen Sound	Brick.
Parks, H. W.	Dresden	Tile.
Paxton & Bray	St. Catharines	Brick.
Pears & Son, James	Toronto	Brick.
Pears, William	West Toronto	Brick.
Peerless Brick & Tile Co., Limited	Ottawa	Brick.
Pembroke Brick Co., The	Pembroke	Brick.
Petty, Chas.	Cherrywood	Brick and Tile.
Phillips, Thos.	St. Helens	Tile.
Phinn, Geo. E.	Lucan	Brick and Tile.
*Pilon, A.	Casselman	Brick.
Ponsford, A. E.	St. Thomas	Brick and Tile.
*Port Arthur Sand-Lime Brick Co., Ltd.	Port Arthur	Sand-Lime Brick.
Port Credit Brick Co., Limited	Port Credit	Common and Pressed Brick.
Port Dover Brick & Tile Co., Limited	Port Dover	Brick and Tile.
Price, John	Toronto	Brick.
Prices, Limited	Toronto	Brick.

* Not working in 1915.

Name.	Address.	Product.
Reed, Mrs. A.	Foxboro	Tile.
Rice, Geo. A.	Dresden	Brick.
Richardson & Son, James	Kerrwood	Brick and Tile.
Ries, John	Carlsruhe	Tile.
Rilett, David	Oil Springs, R.R. No. 3.	Tile.
Rowntree, Josiah	Mount Dennis	Brick.
*Russell, Joseph	Toronto	Brick.
*Russell Brick & Tile Co., Limited	Russell	Brick and Tile.
Schaefer Brick Co., Limited	New Hamburg	Brick and Tile.
Schultz Bros. Co., Limited	Brantford	Sand-Lime Brick.
*Scott, James M.	Meaford	Brick and Tile.
Silicate Brick Co. of Ottawa, Ltd.	Ottawa	Sand-Lime Brick.
Sinden, L. H.	Tillsonburg	Brick and Tile.
Sipprell, J. H.	Wilkesport	Brick and Tile.
Smith, Allan G. C.	Acton	Cement Blocks and Tile.
Smith & Son, Alex.	Dutton	Brick and Tile.
*Smith, W. W.	Shallow Lake	Brick and Tile.
Smith Bros.	Port Elgin	Brick.
Snelgrove & Teer	Beaverton	Brick and Tile.
Sproat, Wm. M.	Seaforth	Tile.
Standard Brick Co., Limited	Toronto	Brick.
Steele, Edwin	Vankleek Hill	Brick.
*Stickwood, Chas.	Newmarket	Brick.
*Sudbury Brick Co., Limited	Sudbury	Brick.
Sun Brick Co., Limited	Toronto	Brick and Hollow Blocks.
*Superior Brick Co., Limited	Fort William	Brick.
Taylor Bros.	Kemptville	Brick and Tile.
Taylor & Hall	Peterboro'	Cement Blocks and Pipe.
*Terra Cotta Pressed Brick Co., Limited.	Terra Cotta	Pressed Brick.
Thornton, John	Perth	Brick.
Toronto Brick Co., Limited	Toronto	Sand-Lime Brick.
Toronto Pressed Brick & Terra Cotta Co. of Milton, Limited	Milton	Pressed Brick.
Voakes, Ed. R.	Wheatley	Brick and Tile.
Wagstaff, A. H.	Toronto	Brick.
Waide Bros.	London	Brick.
Waite, J. E.	Foresters Falls	Brick and Tile.
*Wallace & Son, R.	North Bay	Brick.
Wallaceburg Brick Co.	Wallaceburg	Brick.
Wardle, John	Blenheim	Brick and Tile.
Watson Brick Co.	Bracebridge	Tile.
Wehlann, Alfred	Cairo	Brick and Tile.
Wehlann & Son	Rodney	Brick and Tile.
Weppler. Henry	Hanover	Brick and Tile.
Wood, W. H.	Brockville	Brick.
*Willcox Lake Brick Co., Limited	Toronto	Sand-Lime Brick.
Wright & Sons, Geo.	Comber	Tile.
Yaeck, Louis	Walkerton	Brick and Tile.
York Sandstone Brick Co., Limited	Toronto	Sand-Lime Brick.

POTTERY PLANTS

Name	Address.
*Belleville Pottery Company	Belleville.
Cranston & Son, John	Hamilton.
Davis & Son, John	Toronto.
Foster Pottery Co.	Hamilton.
Humberstone, Thos. A.	Newtonbrook.
Taylor, Geo. N.	Port Hope.

*Not operating in 1915.

Sewer Pipe

The three plants for the manufacture of sewer pipe produced $391,837 worth of pipe last year, and sold $361,283 worth. This is a considerable falling off from 1914, when the sales amounted to $571,756.

The names and addresses of the companies are as follows:—

SEWER PIPE MANUFACTURERS

Name.	Address.
The Dominion Sewer Pipe Co., Limited	Swansea.
The Hamilton & Toronto Sewer Pipe Co., Limited	Hamilton.
The Ontario Sewer Pipe Company, Limited	Mimico.

Lime

The production for 1915 was 1,340,394 bushels valued at $244,953 as compared with 2,075,228 bushels worth $333,407 for 1914.

Works in operation numbered 29. It will be seen from the list of producers that a number were idle during the year. Small producers are gradually going out of business, the demand for lime being met by larger and better equipped plants.

For firing the kilns, wood, coal and natural gas are used as fuel, the total value of which amounted to $60,705 in 1915. Employees engaged in lime manufacture numbered 158 and received $90,808 in wages.

Below are given the names of producers and the location of plants in Ontario:

LIME PRODUCERS

Name of Owner or Company.	Location.
Annis, Geo.	South Orillia.
*Baker, Edwin B.	Winchester.
Beachville White Lime Co., Limited	Beachville.
Beauchamp, F. X.	Dalhousie Mills.
Bergin, Patrick	Napanee.
Brown, E. A.	Owen Sound.
*Callan & Bros., John	Innerkip.
Cameron, W. M.	Carleton Place.
Canada Lime Company, Limited	Coboconk.
Chalmers, Mrs. Margaret	Owen Sound.
Chestnut, W. D.	Duntroon.
Delta Lime Co., Limited	Delta.
*Duckett, J. H.	Eugenia.
Flieler, E. & F.	Fernleigh.
*Frey, David S.	Elmira.
Harvey Limited, E.	Rockwood.
Higginson & Stevens	Hawkesbury.
Jamieson Lime Co.	Renfrew.
Lavoie, Alfred	St. Felix.
Leslie, A. E.	Puslinch.
*Lime Agencies, Limited	Port Colborne.
*Lumsden, G. D.	Holstein.
MacTernan, John	Dirleton.
McGilvray, Jas.	Priceville.

* Idle in 1915.

LIME PRODUCERS—Continued

Name of Owner or Company.	Location.
McKenzie Bros.	Lucknow.
McMillan, Fred.	Havelock.
Marshall Lime and Cement Works, Jas.	Hamilton.
Milton, Peter	Campbellford.
*Moore, Jos.	Foxmead.
*Oneida Lime Co., Limited	Hamilton.
*Ontario Limestone & Clay Co., Limited	Belleville.
*Parks & Sons, R. B.	Troy.
*Poirier, Emerie	Apple Hill.
*Poole, T. A.	Perth.
Robertson Co., Limited, D.	Milton.
Robillard & Son, H.	Ottawa.
Smith, John S.	Inverhuron.
Standard Chemical, Iron & Lumber Co., Limited	Eganville.
Standard White Lime Co., Limited	Beachville, Guelph, and St. Marys.
Toronto Lime Company, Limited	Limehouse and Dolly Varden.
*Walker, Jay	Uhthoff.
Wellman, Albert	Bellview.

* Idle in 1915.

Portland Cement

Compared with other construction materials the decrease in production of Portland cement in 1915 was not great. There were 2,302,242 barrels marketed worth $2,534,537. For 1914 the figures were 2,665,650 barrels valued at $2,931,190. The average price per barrel was practically the same as for 1914, or $1.10 nearly. Cement on hand at the end of the year amounted to 755,799 barrels.

The following cement plants operated in 1915:—

PORTLAND CEMENT PLANTS

Name of Company.	Location of Plant.	P.O. Address of Manager, etc.
Canada Cement Company, Limited, Plant No. 4..	near Belleville	Herald Bldg., Montreal, Que.
do do do No. 5..	near Belleville	do do
do do do No. 8..	near Port Colborne ..	do do
The Hanover Portland Cement Co., Limited	Hanover	Hanover.
National Portland Cement Co., Limited	Durham	Durham.
The Ontario Portland Cement Co., Limited	Blue Lake	Brantford.
St. Marys Portland Cement Co., Limited	St. Marys	St. Marys.

Sand and Gravel

Deposits of sand and gravel are widely distributed throughout the Province, both on land and in the beds of the great lakes and connecting rivers. Regulations governing the leasing of lands containing sand and gravel situated under the waters of the great lakes, etc., were approved by Order-in-Council dated April 30th, 1912. Since that date licenses authorizing the removal of such sand and gravel have been issued. In addition to the annual fee of $100 licensees pay

a royalty or charge per cubic yard on sand or gravel removed, depending in amount on the location of the deposit, distance from market and other circumstances. At the conclusion of the section of this Report dealing with the Mines of Ontario is appended a list of sand and gravel operators whose excavations were inspected during the year.

The following, chiefly individuals or companies operating under license, have made returns to the Bureau of Mines:—

SAND AND GRAVEL OPERATORS, 1915

Name.	Material.	Address.
Armstrong Supply Co., Limited	Sand and Gravel	Hamilton.
Barnes, Wm.	Sand	Hamilton.
Cadwell Dredging Co., Limited	Gravel	Windsor.
Canadian Sand & Gravel Co., Limited	Gravel	Thorold.
Cooper, W. H.	Sand and Gravel	Hamilton.
Empire Limestone Co.	Sand	Buffalo, N.Y.
Goodale, Emerson	Sand and Gravel	Hamilton.
Gould, Francis E.	Sand and Gravel	Cleveland, O.
Hagerman, Anson V.	Sand	Odessa.
Hansen, H. C.	Sand and Gravel	Cleveland, O.
Kingston Sand and Gravel Co.	Sand	Kingston.
Niagara Sand Corporation	Gravel	Welland.
Ollman Bros.	Gravel	Hamilton.
Oneida Lime Co., Limited	Sand	Buffalo, N.Y.
Smith, G. R.	Gravel	Dunnville.
Soo Dredging and Construction Co., Ltd.	Gravel	Sault Ste. Marie.
Superior Sand and Gravel Co.	Gravel	Detroit, Mich.
Superior Sand and Towing Co.	Sand	Port Arthur.
United Fuel and Supply Co.	Sand and Gravel	Detroit, Mich.
Windsor Sand and Gravel Co., Limited	Sand and Gravel	Walkerville.
York Sand and Gravel Co., Limited	Gravel	Toronto.

Stone

Classified according to variety rather than to uses, the quarry products of the Province for 1915 were approximately as follows:—

——	Limestone.	Sandstone.	Trap.	Granite.	Marble.	Quartz.
Value $	587,000	5,500	32,100	15,500	10,600	142,400

Limestone is by far the most important, both as to variety of uses and value of production. The above valuation does not include limestone quarried for lime manufacture. Sandstone is not much used, for the reason that good quarrying beds are not found extensively in older Ontario. Trap is a hard, tough, volcanic rock admirably suited for road metal when crushed. It is used extensively also for concrete road construction, although cheaper varieties of crushed stone serve for most concrete work. Long freight hauls increase the price of trap to so high a figure that its use in certain parts of the Province will never become general. Granite is quarried chiefly for paving blocks. The ornamental marble in Ontario comes from Hastings and Lanark counties, while white marble is quarried in

Hastings and Renfrew. Quartz production shows a considerable increase in production. By far the greater part of the output is used by the Canadian Copper Co. as a smelter flux in the production of nickel-copper matte. In the Coniston smelter the Mond Company use quartz obtained from Bruce Mines. This quartz carries copper which is recovered in the nickel-copper matte.

Below are given lists of firms or companies operating quarries:—

GRANITE, MARBLE AND TRAP QUARRIES

Name of Owner, Firm or Company.	Location.	Kind of Stone.
Bannerman & Horne	Ignace and Butler	Granite Blocks.
*Canadian Marble Co., Limited	Bancroft	.....
Canadian Towing & Wrecking Co., Limited	Port Arthur	Trap.
*Central Ontario Granite and Marble Co., Limited	Bancroft	.....
Gordon & Bruce	Lyndhurst	Granite.
Granite, Crushed and Dimension, Limited	Washago	Granite.
*Hastings Quarries	Tweed	Marble.
Intercities Quarries Co., Limited	Port Arthur	Trap.
*Martin International Trap Rock Co., Limited	Bruce Mines	Trap.
*North Lanark Marble and Granite Quarries	Marble Bluff	.....
Ontario Marble Quarries, Limited	Bancroft	Marble.
Ontario Rock Co., Limited	Preneveau	Trap.
Superior Sand and Towing Co., Limited	Port Arthur	Trap.
Thunder Bay Contracting Co., Limited	Port Arthur	Trap.
White Marble Co. of Canada, Limited	Haley Station	Marble.

QUARTZ QUARRIES

Name of Owner, Firm or Company.	Location of Mines.	P.O. Address of Manager, etc.
The Canadian Copper Company, Limited	Dill	42 Exchange Place, New York.
Kingston Feldspar & Mining Co., Limited	Desert Lake and Reynolds mines	Kingston.
The McPhail & Wright Construction Co., Ltd.	Mile 19, A. C. Ry.	Sault Ste. Marie.
Willmott & Company	Killarney	404 Lumsden Bldg., Toronto.

LIMESTONE AND SANDSTONE QUARRIES

Name of Owner, Firm or Company.	Location.	Kind of Stone.
*Battle, Joseph	Thorold	Limestone.
Beachville White Lime Co., Limited	Beachville	do
Bergin, Patrick	Napanee	Rubble, etc.
Britnell & Co., Limited	Burnt River	Limestone.
*Callan & Bros., John	Innerkip	do
Canada Crushed Stone Corporation, Limited	Dundas	do
*Canada Iron Corporation, Limited	Longford Mills	do
*Canadian Quarries & Construction Co., Limited	Ottawa	Sandstone.
*Canadian Quarries, Limited	Hamilton	Limestone.
Cartmell, Wm. R.	Thorold	do
Coast & Lakes Contracting Corporation	Windmill Point	do
Cook, J. S.	Wiarton	do

*Idle in 1915.

LIMESTONE AND SANDSTONE QUARRIES—Continued

Name of Owner, Firm or Company.	Location.	Kind of Stone.
*Coughlin, D.	Smiths Falls	Limestone.
Empire Limestone Co., Limited	Sherkston	do
Farr, L. G.	Haileybury	do
*Fleming, J. H.	Glenwilliams	Sandstone.
Fretz, Jacob M.	Vineland	Limestone.
Gallagher Lime & Stone Company, Limited	Hamilton	do
*Gosselin, Chas.	Quarries	do
Hagersville Contracting Co., Limited	Hagersville	do
Hagersville Crushed Stone Co., Limited	Hagersville	do
Hamilton Works Department	Hamilton	do, crushed.
Hastings Quarries, Limited	Actinolite	do
*Harrison & Beatty	Owen Sound	do
*Howey, George	Nanticoke	Blue Limestone.
Kennedy, R. C.	Guelph	Limestone.
Kingston Penitentiary	Portsmouth	do
*Lally Estate	Smithville	do
*Logan, Hugh	Georgetown	Sandstone.
Longford Quarry Co., Limited	Longford Mills	Limestone.
Maloney, John	Puslinch	do
Marshall, James	Hamilton	do
*Michigan Central Railway	Hagersville	do
Murphy, J. S.	Tweed	do
Oliver-Rogers Stone Co., Limited	Owen Sound	do
*Ontario Limestone & Clay Co. Limited	Belleville	do
Perkins, Geo. A.	Owen Sound	do
Point Anne Quarries, Limited	Point Anne	do
Queenston Quarry Co., Limited	St. Davids	do
Quinlan & Robertson, Limited	Crookston	do
Reid, Fenton	Odessa	Rubble.
Robertson, D., & Company, Limited	Milton	Sandstone.
Robillard, H., & Son	Ottawa	Limestone.
Roddy & Monk	Kingston	do
Rogers, F., & Company	Terra Cotta	Sandstone.
*Rubel Bros.	Jordan	Limestone.
St. Marys Horse Shoe Quarry, Limited	St. Marys	do
Standard Crushed Stone Company, Limited	Niagara Falls	do
Standard White Lime Co., Limited	Beachville, Guelph, and St. Marys	do
*T. Sidney Kirby Co., Limited	Ottawa	Sandstone and Limestone.
Thames Quarry Company, Limited	St. Marys	Limestone.
*Thebault, A.	Ottawa South	do
Tietz, Wm. A.	Waterford	do
Walker Bros.	Thorold	do
*Webber, John, Sr.	Dunnville	do
Webster, James S.	Galt	do
*Welk, Herman	Eganville	do
Welland County Lime Works Co., Limited	Port Colborne	do
Wentworth Quarry Co., Limited	Vinemount	do
William Markus, Limited	Pembroke	do
Wilson, G. S.	Manion	Sandstone.

*Idle in 1915.

Arsenic

Since the commencement of mining operations at Cobalt, white arsenic or arsenious acid has been produced from cobalt-nickel arsenides. The ore for the most part has been treated at southern Ontario silver refineries. Grey arsenic, which is an impure form of white arsenic, and metallic arsenic, are also produced

to a limited extent. At the present time these arsenide ores are treated by the Deloro Smelting and Refining Company and the Coniagas Reduction Company at the refineries situated, respectively, at Deloro and Thorold, also at the Welland plant of Metals Chemical, Limited.

For the past five years the shipments of arsenic in its various forms have been as follows:—

Year.	lbs.	Value. $
1911	4,234,000	74,609
1912	3,927,347	79,297
1913	2,450,758	64,146
1914	4,059,868	116,624
1915	4,980,659	148,379

Calcium Carbide

There are two plants producing calcium carbide in the Province, those of the Canada Carbide Company at Merritton and of the Union Carbide Company at Welland. The capacity of the first mentioned is small compared with that of the same company's plant in the Province of Quebec which utilizes electric power from Shawinigan falls. Cheap electric energy is essential for the economic production of carbide, and power from Niagara is used at the Welland and Merritton plants.

Calcium carbide is a product of the electric furnace, lime and some form of carbon being the raw materials. Acetylene gas, resulting from the contact of water with carbide, is used to some extent in mine lamps, and for lighting buoys as aids to navigation. It is used also for lighting buildings where electricity or illuminating gas are not available. Another use for carbide is in the cyanamid process for the fixation of atmospheric nitrogen, which was described on pages 51 and 52 of the last annual report.

As coke and limestone, the raw materials used in the manufacture of calcium carbide, are largely imported from the United States, it has been deemed advisable to discontinue the inclusion of this product in the tables showing the mineral output of the Province.

Corundum

The market for corundum continues depressed. Carborundum, an electric furnace product, has interfered with the use of the natural abrasive. Shipments of refined corundum have fallen from 1,177 tons in 1913 to 548 in 1914 and to 262 tons in 1915, the value of the 1915 product marketed being $31,398.34.

At present, the only mines in operation are those of the Manufacturers' Corundum Company situated near Craigmont in the townships of Raglan and Carlow.

Feldspar

Feldspar production for 1915 shows a decline, there being 12,649 tons shipped as against 18,062 tons for 1914. Most of the product goes to the potteries of New Jersey and Ohio. There were only two shippers in 1915—the Kingston

Feldspar and Mining Co. from Desert lake and Reynolds mines, and the Canada Feldspar Corporation, Limited, from Verona. The first mentioned and largest producer ships to a grinding mill at Genesee Dock near Charlotte, N.Y. Some of this ground feldspar comes back to Ontario and is utilized by the Frontenac Floor and Wall Tile Co. of Kingston, which operated continuously during 1915. The Dominion Feldspar Company operate a grinding mill near Parham station, but little work was done in 1915. Feldspar, high in potash, is in good demand for the manufacture of chemicals.

Towards the close of the year a feldspar deposit, known as the Victoria quarry, was opened in Frontenac county about 3 miles west of Crow Lake station on the C. P. railway. More detailed reference to this property appears in the Mining Inspector's report, page 132.

Investigations were continued by Prof. Drury of Queen's University, Kingston, in the use of "Drury Slag," which is a blast furnace product, finely ground. It is a mixture of limestone, iron ore and feldspar. Experiments with this fertilizer were conducted at the Ontario Agricultural College farm, Guelph, by Prof. Harcourt, of the Chemistry Department, who reports as follows:

The results of the experiments in 1915 were not conclusive. We did get some good results and some negative. Of course, such may be true with almost any experiment. On the whole, I may say that our experiments lead us to think that we shall get good results from the use of this material.

The potash fertilizer is not on the market as yet.

Graphite

Only two graphite mines shipped in 1915, namely the Black Donald Graphite Company, Limited, near Calabogie, and the National Graphite, Limited, at Maynooth. Both companies mill and refine the mine product. The 1914 production showed an appreciable decrease from 1913, when 1,788 tons of refined graphite were shipped. The 1915 figures, 2,533½ tons valued at $115,274, show a decided increase in output. This is due to other sources of supply being shut off as a result of the Mexican revolution, and also to the curtailment of foreign shipments from Ceylon and Korea.

Regulations by the Dominion Government, respecting the exportation of flake graphite suitable for the manufacture of crucible steel, have been in force since the fall of 1914. Export is allowed to countries allied with Britain, and also to the United States under conditions satisfactory to the Minister of Customs.

Graphite mines in Ontario, situated in the counties of Renfrew and Hastings respectively and producing in 1915, were as follows:—

GRAPHITE MINES

Owner or Company.	Location of Mine or Works.	P.O. Address of Manager, etc.
Black Donald Graphite Co., Limited	Whitefish lake	Calabogie.
National Graphite, Limited	Maynooth and Harcourt.	Maynooth.

Gypsum

From the deposits situated in the valley of the Grand river, Haldimand county, 85,414 tons of crude gypsum were mined in 1915. Two companies are operating, neither of which makes shipments in the crude or lump form. Of the total tonnage, 46,026 were crushed, 1,942 ground and 25,404 tons ground and calcined before shipment. Crushed gypsum is used as a "retarder" in Portland cement and ground gypsum as land plaster for fertilizing. The ground and calcined variety is used in the manufacture of wall plaster, alabastine, and other gypsum products.

The following firms employ 139 men and paid wages amounting to $65,312 in 1915.

GYPSUM MINES

Company or Firm.	Location of Mines.	P.O. Address.
The Alabastine Co. of Paris, Limited	Caledonia	Paris.
Crown Gypsum Company, Limited	Lythmore	Lythmore.

Iron Pyrites

An upward trend in pyrite shipments, beginning in 1913, has continued steadily to date. The 1915 production was more than double that for 1913. The increase can be attributed to the war, the production for 1915 being 145,315 tons, valued at $353,498, as compared with 107,258 tons in 1914, worth $264,722. From the mine of the Northern Pyrites Company at Northpines, near Superior Junction on the National Transcontinental railway, a tonnage was shipped nearly equal in amount to the total shipments from all the mines of the Province for 1914.

Prohibitive ocean freight rates from Europe to the United States have restricted imports to the latter company of both pyrites and sulphur, and in consequence there has been a brisk demand for iron pyrites from Ontario. In addition to the United States markets, the Nichols Chemical Company and the Grasselli Chemical Company are purchasers of Ontario pyrite for treatment in their acid plants at Sulphide and Hamilton respectively.

Pyrites containing 31 per cent. or more of sulphur can be used profitably in the manufacture of sulphuric acid, which with salt and coal form the foundation of the chemical industry.

In addition to the list of 1915 shippers given below, the Goudreau mine on the Algoma Central railway, operated by the Madoc Mining Company, will be ready to ship pyrite in considerable amounts in 1916.

IRON PYRITE SHIPPERS, 1915

Name of Owner, Firm or Company.	Location or Name of Mine.	P.O. Address of Manager, etc.
Algoma Steel Corporation, Limited	Helen	Sault Ste. Marie.
Canadian Sulphur Ore Company, Limited	Queensboro	404 Lumsden Building, Toronto.
Nichols Chemical Company, Limited	Sulphide	Sulphide.
Northern Pyrites Company, Limited	Vermilion lake	Northpines.

Mica

Mica production in 1915 amounted to 195 tons of rough-cobbed and thumb-trimmed, valued at $33,490. The price was considerably higher than in 1914, although the tonnage showed a marked decrease, owing to restricted demand from the largest users. As in former years, the chief producer is the Loughborough Mining Company, near Sydenham, Frontenac county. This company operates the Lacey, which is the largest mica mine in the world, the product being used largely in the manufacture of electrical apparatus.

Several properties were operated during part of the year but the only individuals or companies reporting shipments in 1915 were as follows:—

Name of Owner or Company.	Name of Mine.	P.O. Address of Manager, etc.
Kent Bros. & J. M. Stoness	Taggart mine	Kingston.
Loughborough Mining Co., Ltd.	Lacey mine	Sydenham.

Natural Gas

The output for 1915 of natural gas is returned as 15,211,523 thousand cubic feet as compared with 14,062,800 for the preceding year. The average value at the place of production was 17.28 cents per M. cu. ft. The increase in output is due in part to the precautions taken by the oil and gas well inspectors. Three inspectors are kept in the field for the purpose of enforcing the statutory regulations regarding the wasting of natural gas and the plugging of abandoned wells. Attention has also been given to pipe lines for the prevention of leakage. John Scott of Petrolia, Jos. W. Beno of Tilbury, and A. E. Near of Gas Line are inspectors respectively for the Lambton, Essex and Kent, and Niagara peninsula oil and gas fields.

During the year 1,734 wells were producing, including 109 new wells drilled during the year. Only 13 new holes proved to be dry. The industry employs 598 men, and wages amounted to $382,401. Some 1,931 miles of gas mains are reported. This mileage would be greatly increased if the distributing pipes in the towns and cities were included.

The total production of natural gas is difficult to obtain with absolute certainty for the reason that the proportional meters used for measuring the gas at high pressure, i.e., pipe line pressure, are quite inaccurate. Low pressure meters on the other hand, according to the Meter Inspection Act, are supposed to be correct to within 3 per cent. A pressure of about 6 ozs. is maintained for domestic service and 2 lbs. for industrial purposes.

The deepest well on record in Ontario was drilled in 1915 on Con. VI, township of Enniskillen. A depth of about 4,000 feet was reached, penetrating to the pre-Cambrian basement, without striking either gas or oil. Heretofore, the deepest hole was 3,777 feet in depth, located at Petrolia and recorded on page 10, Vol. XXIV, Part 2, Report of the Ontario Bureau of Mines, 1915.

J. W. Beno, inspector of the Essex and Kent gas field, reports that seven companies or individuals are operating 216 producing gas wells. Some 387 miles

of pipe line ranging in size from 3 in. to 12 in. are used for distributing the gas. Two large pumping plants in the Tilbury East field at Glenwood and Port Alma are operated respectively by the Southern Ontario and Union natural gas companies.

A. E. Near, inspector for the Welland gas field, reports as follows:—

Considerable drilling has been done during the year 1915, which has resulted in securing an additional amount of gas. Among the gas companies in operation the two largest producers are the Dominion Natural Gas Company of Hamilton, and the Provincial Natural Gas and Fuel Company of Niagara Falls, Ontario.

The Dominion Natural Gas Company drilled, during the year 1915, five wells, of which three were producing. They also purchased one well, and abandoned six wells, leaving them at the close of the year with a total number of 347 producing wells. The total open flow production from their own wells was 20,455 M cu. feet per day. This, together with 1,037,980 M cu. feet purchased, supplied upwards of 31,350 customers during the year. This company also receives a considerable quantity of gas from the Southern Ontario Gas Co., Limited, the product from the Tilbury gas field, which contains sulphur. This gas, however, is being supplied to Hamilton manufacturers only, and not for domestic use in that city. Gas from the Tilbury field is also being supplied to Brantford, Paris, Galt, and other places along the line.

The Provincial Natural Gas and Fuel Company during the past year drilled 19 wells in Welland County gas field, of which 13 were producing wells, making a total of 225 producing wells owned by this company. The total product of gas from these wells was 660,577 M cu. feet, which enabled them to give a very satisfactory supply to their 5,879 customers in the city of Niagara Falls, the towns of Welland and Bridgeburg, and the villages of Fort Erie, Stevensville and Crystal Beach.

During the year 1915 a new company was organized under the name of Relief Gas Company, Limited, of St. Catharines. This company drilled in the townships of Gainsboro, Wainfleet and Pelham, 25 producing wells having an aggregate open flow of about 3,328,800 cu. feet of gas, and have also recently laid a pipe line from this field into the city of St. Catharines. In this line are three miles of 10-inch pipe, twelve miles of 8-inch, five miles of 6-inch, and five miles of 4-inch, a total of about twenty-five miles.

The list of natural gas producers for 1915 was as follows:—

NATURAL GAS PRODUCERS

Name of Person or Company.	Township.	P.O. Address of Manager, etc.
Aldrich Gas & Oil Company, Limited, The	Rainham	Hamilton.
Aikens & Beck.	S. Cayuga	Dunnville.
Barnard, Argue, Roth & Stearns Oil & Gas Co.		401 Iroquois Bldg., Buffalo, N.Y.
*Beaver Oil & Gas Co., Limited, The	Romney	Buffalo, N.Y.
Berry, R. N.	Glanford, Binbrook, and Seneca	Caledonia.
Bertie Natural Gas Company, Limited	Bertie	Ridgeway.
Buffalo & Dunnville Oil & Gas Co., Ltd.	Moulton	Buffalo, N.Y.
Canadian Gas Company, Limited	Romney, Tilbury E. and Raleigh	1426 Dime Bank Bldg., Detroit, Mich.
Canfield Natural Gas Company, Limited	North Cayuga	Canfield.
Chippawa Development Co., Ltd.	Willoughby	Chippawa.
Chippawa Oil & Gas Co., Ltd.	Caistor, Canboro, and Cayuga	Kitchener.
Coleman, J. A.	Wainfleet	Wellandport.
Commonwealth Oil and Gas Co., Limited	Onondaga	240 King St. East, Hamilton.
Crystal City Oil and Gas Co., Limited, The	Onondaga	Paris.
Danskin, D.	Brantford	Cainsville.
Deagle, John	Onondaga	Middleport.

* This company is controlled from the head office of the Dominion Natural Gas Company, Limited, 842 Marine Bank Building, Buffalo, N.Y.

NATURAL GAS PRODUCERS—Continued

Name of Person or Company.	Township.	P.O. Address of Manager, etc.
Dominion Natural Gas Co., Limited, The	Lincoln, Wentworth, Elgin, Norfolk and Haldimand (counties)	842 Marine Bank Bldg., Buffalo, N.Y.
Douglas, W. A.		Caledonia.
Dunn Natural Gas Company, Limited, The	Dunn	Dunnville.
Duxbury, Wellington	Walpole	Hagersville.
Eastside Gas Co., Limited	Sherbrooke	Lowbanks.
Emerson, Troughton & Laidlaw	Canboro	Attercliffe Station.
Empire Limestone Company, Limited	Humberstone	Buffalo, N.Y.
*Enterprise Gas Company, Limited	Norfolk (county)	Buffalo, N.Y.
Fairbank Estate, J. H.	Enniskillen	Petrolia.
Fisherville Gas Co. No. 1	Fisherville (village)	Fisherville.
*Glenwood Natural Gas Co., Limited	Raleigh, Romney and Tilbury East	Buffalo, N.Y.
Hager, Ham	Onondaga	Middleport.
Hamilton, Alex. M.	Onondaga	Cainsville.
Hart & Harrington	Canboro	Attercliffe Station.
Hendee Natural Gas Co.	South Cayuga	Cayuga.
Holmes Gas Company, Limited	Rainham and Walpole	Selkirk.
Hoover, D. E.	Rainham	Selkirk.
Hoover, D. E., A. E., and Menno	Rainham	Selkirk.
Hoover, James E.	Walpole	Selkirk.
Hyde, F. W.	Sherbrooke	Dunnville.
Hyde & Snively	South Cayuga	Dunnville.
Industrial Natural Gas Company, Limited	Crowland and Humberstone	Dunnville.
Jasperson, B.	Kingsville (town)	Kingsville.
Jones, James S.	Port Maitland (village)	Port Maitland.
Jones, Nelson	Haldimand (county)	Attercliffe Station.
Kindy Gas Co., Limited	Rainham	Cayuga.
Kindy & Sons, D.	Rainham	Selkirk.
Kohler and Aikens	Canboro	Dunnville.
Lalor, F. R.	Moulton	Dunnville.
Lalor & Vokes	Nanticoke (village)	Dunnville.
Lamb, Alfred	Walpole	Selkirk.
Lamb, Walter B.	Walpole	Nanticoke.
Liesinger-Lembke Co.	Humberstone	Buffalo, N.Y.
Maple City Oil & Gas Co., Limited	Raleigh, Romney, Tilbury East	Buffalo, N.Y.
Marshall James	Haldimand (county)	Hamilton.
Martin, Edward	Port Maitland	Dunnville.
Medina Natural Gas Company, Limited, The	Elgin (county)	Vienna.
Midfield Natural Gas Company, Limited	North Cayuga	32 Stinson Street, Hamilton.
Mickle, Geo. T., & McKechnie, S.	Canboro	Ridgetown.
Moote, Melick and Lymburner	Canboro	Canboro.
Nanticoke Natural Gas Co., Limited, The	Walpole	Nanticoke.
National Gas Company, Limited	Rainham, Seneca	503 Bank of Hamilton Bldg., Hamilton.
Niagara Natural Gas and Fuel Co., Limited	Humberstone	Sherkston.
*Norfolk Gas Company, Limited	Norfolk (county)	Buffalo, N.Y.
North Shore Gas Company, Limited	Rainham	Hamilton.
Northwestern Gas Company, Limited	Brant (county)	13 Scott Block, Erie, Pa.
Oil Springs Oil & Gas Co., Ltd.	Enniskillen	Oil Springs.
Onondaga Oil and Gas Co., Limited	Onondaga	Brantford.

* These companies are controlled from the head office of the Dominion Natural Gas Company, Limited, 842 Marine Bank Building, Buffalo, N.Y.

NATURAL GAS PRODUCERS—Continued

Name of Person or Company.	Township.	P.O. Address of Manager, etc.
Port Colborne-Welland Natural Gas and Oil Company, Limited	Seneca, Oneida, Onondaga	Port Colborne.
*Port Rowan Natural Gas Company, Limited	Norfolk (county)	Buffalo, N.Y.
*Producers Natural Gas Company, Limited	Haldimand (county)	Buffalo, N.Y.
Provincial Natural Gas and Fuel Company of Ontario, Limited	Welland (county)	Niagara Falls.
Relief Gas Co., Limited	Gainsboro, Wainfleet and Pelham	St. Catharines.
Robinson Road Gas Co.	Canboro and Moulton	Dunnville.
Rolston, James	Canboro	Dunnville.
Rose & Patterson	Seneca	Blackheath.
Snively, F. L.	Rainham and South Cayuga	Dunnville.
Sparham, Andrew		Blackheath.
Springvale Oil & Gas Co., Ltd.	Walpole	Hagersville.
Standard Natural Gas Company, Limited	Onondaga	Dunnville.
*Standard Oil Company of Canada, Limited	Kent (county)	Buffalo, N.Y.
Sterling Gas Company, Limited	Humberstone, Wainfleet and Moulton	Port Colborne.
Stevensville Natural Gas & Fuel Co.	Bertie	Stevensville.
Sundy Gas Well Company	Canboro	Dunnville.
Telephone City Oil and Gas Co., Limited	Onondaga	Hamilton.
Union Natural Gas Co. of Canada, Limited	Kent and Lambton (counties)	Niagara Falls.
United Gas Companies, Limited	Wainfleet and Moulton	St. Catharines.
Vansickle, A. W.	Onondaga	Cainsville.
*Waines & Root Gas Co., Limited	Canboro, S. Cayuga, Dunn, Rainham and Walpole	Buffalo, N.Y.
Welland County Lime Works Co., Limited	Wainfleet	Port Colborne.
Wedrick, M.	Walpole	Nanticoke.

* These companies are controlled from the head office of the Dominion Natural Gas Company, Limited, 842 Marine Bank Building, Buffalo, N.Y.

PIPE LINE COMPANIES OR DISTRIBUTORS ONLY OF NATURAL GAS

Brantford Gas Company, Limited.
Central Pipe Line Company, Limited.
Chatham Gas Co., Ltd.
Independent Natural Gas Co., Dunnville.
Ingersoll Gas Light Company, Limited.
Lake Shore Natural Gas Company.
Manufacturers' Natural Gas Company, Buffalo, N.Y.
Nelles Corners Gas Company.
Northern Pipe Line Co., Limited.
Petrolia Utilities Co., Ltd.
Port Colborne-Welland Natural Gas Company.
Regah Natural Gas Co.
Rose Hill Natural Gas Co.
Sarnia Gas & Electric Light Co., Ltd.
Southern Ontario Gas Co., Ltd., St. Thomas.
Thorold Gas Company, St. Catharines.
Tilbury Town Gas Company.
Town of Leamington.
United Gas & Fuel Co. of Hamilton, Ltd.
Wellandport Natural Gas Co., Wellandport.
Windsor Gas Co., Ltd.
Woodstock Gas Light Company, Limited.

The following information regarding the natural gas industry in 1915 has been supplied by G. R. Mickle, Mine Assessor:—

There was no important development in the natural gas production during this year. The increase of output over the previous year amounted to about 8 per cent., and the yield was distributed amongst the following different fields:—

	Million cubic feet.		
(1) Welland-Haldimand, etc.	3,592.9	or	23.6 per cent.
(2) Kent	10,819.1	or	71.1 " "
(3) Elgin	399.1	or	2.6 " "
(4) Lambton	401.2	or	2.7 " "
Total	15,212.3*	or	100.0 per cent.

The percentages derived from the first two fields are almost the same as for the previous year, while Elgin shows a decrease and Lambton an increase.

(1) The first field mentioned comprises productive areas scattered through the counties of Welland, Haldimand, Norfolk, Brant, and Wentworth, and is nearing exhaustion in some parts. There are over sixty producing companies or individuals; most of these are quite unimportant, as five companies are responsible for about two-thirds of this production. The total yield from this field up to the end of 1915 cannot be given with any degree of accuracy, as no records were kept in the earlier years of the productive life of the field. From 1906 to 1915, both inclusive, the production has been 36,906 million cu. ft. Estimating, however, from information given in the Reports of the Bureau of Mines, and checking this with the records of the Provincial Natural Gas and Fuel Company, which was the pioneer, and much the most important producer in the early life of this field, the following approximation is arrived at. Starting about 1892 there were approximately 16,000 million cu. ft. produced prior to 1906, making in all nearly 54 thousand million cu. ft. from Welland-Haldimand, etc.

(2) The Kent gas field appeared for the first time as a producer in 1907, and up to the end of 1915 has yielded 52,049 million cu. ft., or nearly as much as from the Welland-Haldimand field with a vastly greater area of productive rock.

(3) The production from the Elgin field, which was developed in 1911, now amounts to 1,913.7 million cu. ft. This field is small in area, the gas in composition being identical with the normal gas from Kent except that it contains no hydrogen sulphide.

(4) The Lambton field at Oil Springs has now produced 570.8 million cu. ft. Unfortunately it does not seem likely to last much longer.

It is interesting to note that the old abandoned Essex gas field, although very small in area, probably not exceedng 3 square miles, was, like the Kent field, very productive, possibly per unit of area equalling or even exceeding the latter. Calculating from the records available in the same way as explained above in connection with the Welland-Haldimand area, about 22.5 thousand million cu. ft. were utilized from the Essex field. In addition there was an enormous waste for some time after the gas was discovered. No reliable estimate can be made of this waste, but it certainly must have constituted a very substantial addition to the amount of gas of which we have a record. If we assume a value of 10c. per thousand for the gas in the field, the value per square mile of area must have exceeded one million dollars easily. A gas field need not be large to be very valuable, and consequently might easily escape discovery for some time.

Petroleum

For the first time in several years an increase is recorded in the production of crude petroleum, namely, 214,442 barrels or 7,505,478 imperial gallons in 1915 as against 7,437,356 gallons in 1914. The value, however, fell off from $337,867 in 1914 to $300,219 in 1915, the average price for 1914 exclusive of bounty being $1.59 per barrel (35 gals.) and $1.40 for 1915. The lowest and highest prices paid in 1915 were $1.28 and $1.68 respectively. A bounty of 1½ cents per Imperial gallon is payable by the Dominion Government on all crude oil produced in Canada. A great and increasing demand for gasolene, and the expanding use of heavier peroleums for fuel purposes, are the chief factors causing the rise in price which took place in the latter part of the year.

* This total includes 800 thousand cu. ft. of gas, being an estimate of the production from a number of private gas wells whose owners make no returns to the Bureau.

The credit for the increased production is due in large measure to the work of inspectors in plugging abandoned and non-paying wells, some of which leak water in addition to wasting gas, thereby reducing the rock pressure. Inspector J. Scott reports the following figures in regard to oil wells:—

Pumped.	Baled.	Not operated.	Abandoned.	Total.
4,890	436	1,400	543	7,269

The Supervisor of crude oil bounties, J. C. Waddell of Petrolia, kindly supplies the following figures showing the production in imperial gallons from the several fields:—

Lambton.	Bothwell.	Dutton.	Tilbury.	Onondaga.	Belle River.	Total.
5,647,894	1,168,829	189,046	445,957	52,160	1,592	7,505,478

Domestic crude petroleum forms only a small part of the raw material required in the manufacture of petroleum products, the bulk of the crude oil used by Canadian refineries being imported from the United States.

The following table shows the operations for the year of the two refineries, the Canadian Oil Co. Limited, Petrolia, and the Imperial Oil Co. Limited, Sarnia, and also gives comparative figures for a five-year period:—

PETROLEUM AND PETROLEUM PRODUCTS, 1911 to 1915

Schedule.	1911	1912	1913	1914	1915
Crude produced....Imp. gal.	10,102,081	8,432,730	7,915,761	7,437,356	7,505,478
Value crude produced $....	353,573	344,537	381,159	337,867	300,219
Crude distilled.... Imp. gal.	38,632,504	46,270,701	53,821,592	73,239,403	84,355,760
Value distilled products. $	2,294,396	3,592,230	3,068,312	3,360,913	3,193,222
Illuminating oil. Imp. gal.	20,240,523	23,090,280	21,415,010	28,817,830	26,261,575
Lubricating oil.. "	4,729,257	5,932,166	6,144,193	6,228,394	7,271,200
Benzine and naphtha "	4,179,575	4,955,022	7,349,015	13,542,383	19,118,334
Gas and fuel oils and tar..... "	4,847,124	6,028,983	10,157,948	10,747,838	23,478,236
Paraffin wax and candles ... ... lb.	5,267,485	8,086,841	10,153,806	11,053,058	9,826,635
Workmen employed. No.	511	699	781	925	723
Wages paid..... $	314,851	436,852	559,556	683,247	564,950

Salt

Salt production in 1915 shows an increase over 1914 figures of 11 per cent. Of the 116,648 tons marketed, valued at $585,022, there were 84,103 tons of fine, table and dairy grades, 31,553 tons of coarse and 992 tons of land salt. The source of supply is from the brine wells of southwestern Ontario. The industry affords employment to 242 men, whose wages amounted to $183,558 in 1915.

It may be pointed out that salt is one of the three basic materials in the chemical industry, the others being coal and sulphur. The chemical plant of the Canadian Salt Company at Sandwich is quite distinct from that for salt manufacture, and promises in a few years' time to be one of the largest in the British Empire.

The following salt producers reported to the Bureau of Mines:—

SALT COMPANIES

Name of Owner, Firm or Company.	Location of Wells or Works.	P.O. Address of Manager, etc.
The Canadian Salt Company, Limited	Windsor / Sandwich	Windsor.
The Dominion Salt Company, Limited	Sarnia	Sarnia.
The Earlton Salt Works Company, Limited	South of Egremont Road	Hyde Park.
Exeter Salt Works Company, Limited	Exeter	Exeter.
North American Chemical Co., Limited	Goderich	P.O. Box 29, Clinton.
John Ransford	Stapleton	Clinton.
Western Canada Flour Mills Co., Limited	Goderich	Goderich.
The Western Salt Company, Limited	Mooretown and Courtright	Courtright.

Talc

Shipments of talc for 1915 exceeded those of 1914, the figures being 1,720 tons of crude and 9,285 tons of ground, with a valuation of $5,760 and $80,165, respectively, as compared with 1,694 tons crude and 8,866 tons ground in 1914. The total valuation of marketed product in 1915 was $85,325. For 1914 the amount was $74,663. Grinding mills are located at Madoc and Eldorado. The entire output of talc came from Hastings county.

Talc operators, the first mentioned company making trial shipments only, are as follows:—

Firm or Company.	Location of Mine or Works.	Address of Manager, etc.
Anglo-American Talc Corporation, Ltd.	Huntington Tp. (Connolly mine).	Madoc.
Cross and Wellington	Huntington Tp. (Henderson mine)	Madoc.
Eldorite, Limited	Eldorado	Eldorado.
Gillespie, G. H., & Co.	Madoc	Madoc.

Mining Companies

The number of companies incorporated in 1915 under the laws of Ontario to carry on mining business in any or all of its branches was much smaller than for the previous year. Companies incorporated were 59 in number and the aggregate capital authorized was $42,005,000. In 1914 the number was 80 with a nominal capitalization of $39,030,000. Only two companies of foreign or federal incorporation were licensed to do business in the Province as compared with thirteen for 1914.

The lists are as follows:—

MINING COMPANIES INCORPORATED IN 1915

Name of Company.	Address.	Date of Incorporation.	Capital.
Adanac Silver Mines, Limited	Toronto	May 15...	$2,500,000
Algoma Nickel Mining Company, Limited	Toronto	Oct. 25...	10,000
Casey Harris Mining Company, Limited	Toronto	Oct. 23...	100,000
Croesus Gold Mines, Limited	Cobalt	Sept. 21...	200,000
Dome Consolidated Mines, Limited	Toronto	Oct. 2...	2,500,000
Elora White Lime Company, Limited	Elora	Sept. 22...	100,000
Empire Sand and Gravel Company, Limited	Toronto	Dec. 16...	40,000
Genesee Mining Company, Limited	Cobalt	July 30...	1,000,000
George Frid Brick Company, Limited	Hamilton	July 15...	40,000
Gould Allied Mines, Limited	Ottawa	Sept. 14...	2,000,000
Gowganda Enterprise Mining Company, Limited	Fort Erie	Sept. 24...	40,000
Haileybury Kirkland Lake Mining Company, Limited	Toronto	Jan. 26...	1,000,000
Harris Development & Exploration Syndicate, Limited	Toronto	Oct. 25...	650,000
Hastings County Marble Company, Limited	Toronto	May 14...	100,000
Imperial Reserve Mines, Limited	Toronto	Sept. 24...	1,500,000
James Gow Lime Kiln, Limited	Fergus	Jan. 5...	60,000
Kirkland Lake Gold Mining Company, Limited	Toronto	Nov. 19...	2,000,000
Knoxwell Mining Company, Limited	Toronto	June 29...	500,000
La Belle Kirkland Mines, Limited	Fort Erie	Sept. 2...	2,000,000
Lady Maud Lake Gold Mines, Limited	New Liskeard	Jan. 18...	500,000
Letson Gold Mines, Limited	Toronto	April 7...	1,000,000
McIntyre Extension Mines, Limited	Toronto	July 15...	2,500,000
McIntyre-Jupiter Mines, Limited	Toronto	Nov. 3...	2,000,000
Mercer Silver Mines, Limited	Toronto	July 12...	1,000,000
Michigan-Ontario Mines, Limited	Windsor	April 19...	100,000
Miller Independence Mines, Limited	Boston Creek	Nov. 17...	500,000
Mount St. Patrick Molybdenite Mines, Limited	Ottawa	June 18...	300,000
Munro Consolidated Gold Mines, Limited	Toronto	Sept. 15...	1,000,000
National Graphite, Limited	Toronto	May 17...	60,000
Newray Mines, Limited	Toronto	Feb. 11...	1,000,000
Northampton Mining Company, Limited	Toronto	Nov. 17...	50,000
Orillia Molybdenum Company, Limited	Orillia	Sept. 13...	200,000
Porcupine Excelsior Mining Company, Limited	Porcupine	Aug. 7...	100,000
Provincial Stone & Supply Company, Limited	Toronto	Nov. 22...	40,000
Relief Gas Company, Limited	St. Catharines	April 15...	40,000
Sable River Copper Company, Limited	Toronto	Dec. 30...	100,000
Shamrock Consolidated Mines, Limited	Toronto	June 25...	1,000,000
Swastika Gold Mines, Limited	Toronto	Dec. 13...	2,000,000
The Belmont Oil and Gas Company, Limited	Belmont	Sept. 29...	40,000
The Bowmanville Gravel Company, Limited	Bowmanville	April 27...	40,000
The Casey-Seneca Silver Mines, Limited	Toronto	April 10...	1,000,000
The Darlington Gravel Company, Limited	Bowmanville	Sept. 14...	40,000
The Darragh-Downey Mining Company, Limited	Ottawa	Feb. 10...	100,000
The Dominion Lime Company, Limited	Madoc	June 8...	100,000
The Elk-Horn Lime Company, Limited	Madoc	Aug. 30...	250,000
The Faced Brick and Machinery Company, Limited	Toronto	May 17...	100,000
The Globe Graphite Mining and Refining Company, Limited	Port Elmsley	Jan. 7...	500,000
The Gold Anchor Mining Company, Limited	Cobalt	April 13...	1,000,000
The Hungerford Talc Company, Limited	Toronto	Feb. 1...	50,000
*The Morse Porcupine Syndicate, Limited	Toronto	Sept. 11...	35,000
The Shanedarr Mining Company, Limited	Ottawa	April 27...	40,000
The Sudbury Leasing & Development Company, Limited	Sudbury	Feb. 23...	40,000
The Sydenham Mica and Phosphate Mining Company, Limited	Kingston	Dec. 24...	50,000
The Vacuum Gas and Oil Company, Limited	Toronto	April 17...	1,000,000

* Name changed to Porcupine Bonanza Mines, Limited, on October 9th, 1915.

MINING COMPANIES INCORPORATED IN 1915—Continued

Name of Company.	Address.	Date of Incorporation.	Capital.
Toronto Gas and Oil Company, Limited	Toronto	July 8...	$40,000
Triumph Mines, Limited	Toronto	Nov. 22...	3,000,000
West Dome Consolidated Mines, Limited	Toronto	Sept. 23...	3,000,000
Whitby Brick and Clay Products Company, Limited	Whitby	May 10...	250,000
Yellow Jacket Gold Mine, Limited	Toronto	Nov. 10...	1,500,000
			$42,005,000

MINING COMPANIES LICENSED IN 1915

Name of Company.	Head Office for Ontario.	Date of License.	Capital for Use in Ontario.
Mond Nickel Company, Limited	Toronto	Jan. 30...	$10,000,000
The North-Thompson (Associated) Gold Mine, Limited	Almonte	Jan. 29...	200,000
			$10,200,000

Mining Divisions

The following is a list of the Mining Divisions of Ontario, names and addresses of the Recorders, and receipts from each Division for the fiscal year ending Oct. 31st, 1915:—

Mining Division.	Name and P.O. Address of Recorder.	Receipts.				Total Receipts.
		Purchase price.	Permit.	Miners' Licenses.	Recording Fees.	
		$ c.	$ c.	$ c.	$ c.	$ c.
Sault Ste. Marie	S. T. Bowker, W. N. Miller, Sault Ste. Marie	1,465 00 554 75	.....	427 10 322 00	64 87 496 75	1,956 97 1,373 50
Sudbury	C. A. Campbell, Sudbury	4,213 90	130 00	2,757 15	2,205 25	9,306 30
Porcupine	G. H. Gauthier, Porcupine	11,720 66	130 00	3,116 40	2,928 75	17,895 81
Larder Lake	J. A. Hough, Matheson	10,607 96	.....	2,570 00	10,106 50	23,284 46
Port Arthur	J. W. Morgan, Port Arthur	9,979 63	40 00	1,862 00	4,605 65	16,487 28
Parry Sound	H. F. McQuire, Parry Sound	161 60	.....	149 00	244 00	554 60
Gowganda	H. E. Sheppard, Gowganda	366 19	60 00	344 00	208 65	978 84
Montreal River	A. Skill, Elk Lake	858 65	10 00	370 00	62 25	1,300 90
Timiskaming (including Coleman)	G. T. Smith, N. J. McAulay, Haileybury	615 25 2,625 67	20 00	5,008 00 1,838 00	743 00 883 75	6,386 25 5,347 42
Kenora	W. L. Spry, Kenora	79½ 50	.....	293 23	260 75	1,346 48
	Total	43,961 76	390 00	19,056 88	22,810 17	86,218 81

The Eastern Ontario and Fort Frances Mining Divisions have no resident Recorders, and all business originating there in connection with recording of claims, etc., is handled by the Bureau of Mines at Toronto. Revenue not derived from the Recording Officers is collected by the Department.

A brief record, as reported by the Recorders, of the activities of the year, in several of the Mining Divisions, follows herewith:—

Sudbury.—There were no new fields of any importance opened up during this last year, but it might be worthy to note that Harry Shepherd of North Bay staked a claim for

molybdenite in lot 10, con. III, Garrow township, and John Mataris also staked claims for the same material in the township of Roberts. During the latter part of the year quite a lot of interest was taken in the nickel region and a number of claims staked.

Porcupine.—There has been an increase in the business transacted in the Recording Office as compared with 1914. Recently prospecting and staking have been active in Deloro and some other portions of the camp, and everything points to considerable activity during the spring and summer of 1916. More real substantial development work is being done on prospects as the camp proves up. In many cases the results obtained have been most encouraging. It is evident that Porcupine's gold production will eventually be much greater than it is at present. During the past year all of the producing mines have increased their output considerably, and three mines have been added to the list of producers, namely, Dome Lake, Schumacher and Acme. The ore from the latter is being treated at the Hollinger mill. There promises to be other producing mines developed during the coming year. The gold production of Porcupine will likely amount to between ten and eleven million dollars in 1916.

Larder Lake.—There was much activity in all parts of this Mining Division during the year 1915. One of the chief features of the year was the finding of high-grade gold ore in Munro township. Remembering that 1915 was supposed to be a year of stringency owing to the war, it is interesting to note that the revenue of this office was greater for the year 1915 than for any previous year.

Port Arthur.—Notwithstanding the depressing effects of the European war, the business in this office is very much in excess of that of 1914; the increased activity being largely due to the discovery of gold in what is now known as "The Kowkash Gold Fields," which lie northeast of the Nipigon Forest Reserve. The Tashota Gold Field, which is said to be very good, is simply a continuation to the west of the Kowkash deposits. A new discovery of gold has also been made quite recently in the northwest part of this Mining Division.

Parry Sound.—There were seventeen claims taken up in Lount township for iron ore by Bay City interests, but little or no work filed during this season. I am informed it is the intention to vigorously prospect these claims during the summer of 1916. In McConkey township there were five claims taken up for mica. Parties are now at work taking out some mica with the view to seeing if it is a commercial success. In Cowper township there were two claims taken up for feldspar, but it was not the intention to make any shipments until the summer of 1916. In Burton township there was also one claim staked for mica.

Mining Revenue

The revenue of the Department for the fiscal year ending Oct. 31st, 1915, was $342,986.44, a decrease of $160,682.11 from the previous year.

Miner's licenses and other fees connected with the recording of mining claims afford a criterion of the activity in prospecting and speculation in mining lands. When a new camp of any importance is discovered the reflection in mining revenue comes in the form of increased receipts.

The following itemized list shows the sources of revenue, also the corresponding receipts for the year ending Oct. 31st, 1914.

	1913-14.	1914-15.
Sales of mining land	$41,027 50	$46,584 88
Rental, leases, etc.	16,469 76	13,841 58
Miners' licenses, permits, fees	64,195 26	52,308 70
Royalties	74,685 11	52,860 60
Mining Tax Act	306,861 40	177,101 53
Provincial Assay Office, etc.	429 52	289 15
	$503,668 55	$342,986 44

The following schedule shows the transactions in mining lands for the fiscal year. It will be noted that the figures do not quite correspond with those given in the summary, since they cover sales, leases, etc., completed during the year, while the summary takes in all moneys collected.

MINING LANDS SOLD AND LEASED

District.	Sales.			Leases.			Total.		
	No.	Acres.	Amount.	No.	Acres.	Amount.	No.	Acres.	Amount.
Timiskaming	273	9,765.86	26,898 34	41	1,407.89	1,407 89	314	11,173.75	28,306 23
Thunder Bay	114	4,553.29	10,665 01	....	.....	.....	114	4,553.29	10,665 01
Algoma	35	1,282.50	3,245 50	....	.....	.....	35	1,282.50	3,245 50
Sudbury	26	1,017.60	2,972 25	10	457.20	457 20	36	1,474.80	3,429 45
Nipissing	1	40.00	120 00	6	226.95	226 95	7	266.95	346 95
Kenora	8	388.00	990 00	....	.....	.....	8	388.00	990 00
Rainy River	1	11.00	11 00	....	.....	.....	1	11.00	11 00
Parry Sound	3	150.00	450 00	....	.....	.....	3	150.00	450 00
Elsewhere	2	69.60	87 00	....	.....	.....	2	69.60	87 00
Total	463	17,277.85	45,439 10	57	2,092.04	2,092 04	520	19,369.89	47,531 14

Royalties.—Cobalt mines paying royalty to the Crown are now only three in number, namely, the O'Brien and Hudson Bay mines under special agreement, and the Crown Reserve under the terms of the original grant. Details as to rates, etc., were outlined in Volumes XX and XXII of the Bureau's Reports on pages 47 and 51 respectively. The payments for the fiscal year ending October 31st, 1915, were as follows:—

Crown Reserve	$22,062 14
O'Brien	23,734 76
Hudson Bay	7,063 70
Total	$52,860 60

Some of the mines paying royalty have ceased operation. In the case of others there has been a decline in production. As a result, revenue in the future from this source will undoubtedly show a decrease.

The total royalties paid by the mines subject to these arrangements, up to the end of the fiscal year, are shown in the following statement:—

Crown Reserve	$793,945 58
O'Brien	724,700 83
Hudson Bay	333,870 05
Chambers-Ferland	26,259 64
Cobalt Provincial	6,735 14
Hargrave	1,200 00
Waldman	777 48
Wyandoh	1,421 72
Total	$1,888,910 44

Certain mining companies at Cobalt, holding lands from the Timiskaming and Northern Ontario Railway Commission, pay a royalty on their output directly to the Commission. The leases, which originally specified a royalty of 25 per cent. at the collar of the shaft, have been reduced gradually to 5 per cent. on the net profits, which rate became effective on Sept. 1st, 1915. For the year ending Oct. 31, 1915, the Commission received from the Mining Corporation of Canada

and the Right of Way Mines $31,341.25 as royalty. Total receipts by the Commission from this source are as follows:—

City of Cobalt	$100,791 13
Cobalt Townsite	279,482 72
Mining Corporation of Canada	39,703 83
Nancy Helen	6,126 60
Right of Way	272,152 19
Total	$698,256 47

Mining Tax Act.—The revenue received under the Mining Tax Act (chapter 26, R.S.O. 1914), for the fiscal year ending Oct. 31st, 1915, together with comparative amounts for the preceding year, was as follows:—

	1913-14.	1914-15.
Acreage Tax	$10,046 41	$10,716 24
Profit Tax	272,610 89	139,978 62
Natural Gas Tax	24,204 40	26,406 53
Totals	$306,861 40	$177,101 53

The 3 per cent. tax on profits of mining companies has yielded in all since the Act came into force, the sum of $1,200,600.07, the amounts by calendar years being as follows:—

1907	$66,741 68	1912	$200,275 25
1908	65,922 48	1913	206,212 77
1909	78,327 58	1914	201,940 20
1910	111,546 17	1915	138,056 19
1911	131,577 75		
		Total	$1,200,600 07

The mines which have paid the tax, and the total amounts paid by each, are as follows:—

Silver Mines.	$ c
Beaver	9,785 85
Buffalo	36,340 70
Casey-Cobalt	4,836 41
Coniagas	114,825 96
Cobalt Silver Queen	4,657 15
Cobalt Comet	1,942 02
Cobalt Lake (Mining Corp'n of Canada)	12,750 60
Drummond	11,788 84
Foster	577 87
Kerr Lake	120,276 30
La Rose	135,519 92
McKinley-Darragh-Savage	77,458 85
Miller-Lake-O'Brien	9,043 96
Nipissing	229,907 56
Penn-Canadian	383 82
Timiskaming	34,052 27
Trethewey	15,153 18
Seneca-Superior	14,429 22
Standard	1,447 00
Watts	258 69
Wettlaufer-Lorrain	19,054 45
Total	$854,490 62

Nickel-Copper Mines.	$ c
Alexo	309 93
Canadian Copper Co.	245,000 00
Mond Nickel Co.	18,226 94
Total	$263,536 87

Gold Mines.	
Dome	9,068 06
Hollinger	62,077 38
McIntyre-Porcupine	1,543 64
Porcupine-Crown	7,983 78
Total	$80,672 86

Miscellaneous.	
Lake Superior Corp'n (iron)	1,683 51
Loughborough Mining Co. (mica)	216 21
Total	$1,899 72

Summary.	
Silver Mines	854,490 62
Nickel-Copper Mines	263,536 87
Gold Mines	80,672 86
Miscellaneous	1,899 72
	$1,200,600 07

The total revenue paid into the treasury of the Province by the Cobalt silver mines, without including the amounts paid to local municipalities under the provisions of the Mining Tax Act, are set forth in detail as follows:—

Royalties paid direct to the Crown	$1,888,910 44
Royalties paid T. & N. O. Railway Commission	698,256 47
Three per cent. Profit Tax	854,490 62
	$3,441,657 53

The Mine Assessor, G. R. Mickle, who has charge of the collection of revenue derived from the Mining Tax Act, furnishes the following notes regarding the operation of the Act for the calendar year 1915:—

Three different taxes are levied under the Act, viz.: (1) the Profit Tax, being three per cent. of the profits in excess of $10,000, computed as explained in the Act; from this is deducted the income tax paid municipalities; (2) Natural Gas Tax, being equivalent to $2.00 per million cu. ft.; and (3) Acreage Tax of two cents per acre on mining lands in districts with no municipal organization. The amounts realized from these various taxes for the calendar year 1915 were as follows:

Profit Tax	$138,056 19
Natural Gas Tax	27,952 61
Acreage Tax (Apr. 15th, 1915, to Apr. 15th, 1916)	12,020 83
Total	$178,029 63

This is a decrease of over $58,000 from the amount received in 1914, the corresponding figure for that year being $236,700.06. The loss is in the profit tax, due to the substantial decrease in the production of silver. This decrease amounted to about 4½ million ounces. Moreover, the average price obtained per ounce was about three cents lower than in the year before, and the working expenses somewhat greater per unit recovered. As the tax is always based on the operations of the preceding year, this decrease in production refers to the year 1914 as against 1913. Moreover, the amounts given above are for the calendar year in which they are payable, and consequently will not agree with the Public Accounts Statement, which deals with the fiscal year for the Province ending on 31st October. As these taxes are not due till October 1st, it has never been possible to collect them all before the end of the fiscal year, consequently it seemed preferable for the purposes of comparing the results from year to year to give them in this way.

With regard to the immediate future there will be a small increase in the profit tax, due to increased production of gold. Natural gas will also yield a small amount more revenue, while the acreage tax remains about the same from year to year, only showing an increase when a list of lands is advertised for forfeiture.

Provincial Assay Office

The Provincial Assayer, W. K. McNeill, reports as follows:—

During the year 1915 the Provincial Assay Office, located at Belleville between 1898 and 1911, now at No. 5 Queen's Park, Toronto, Ontario, carried on its work along the usual lines. This work includes:—

(*a*) Examination and assaying of samples from mining engineers, prospectors, geologists and the public generally. This covers a wide range of work.

(*b*) Work for the Ontario Bureau of Mines consisting of analyses of rocks, assaying of different ores and identification of minerals for the various geologists in the employ of the Bureau of Mines.

(*c*) Testing samples submitted by the public for radium. This work is done free of charge.

(*d*) Sampling car lots of cobalt-silver ore shipped from the mines upon which the Government collects a royalty. This necessitates having a sampler at Deloro for a large portion of the time.

(*e*) Assaying and valuation of these car lots.

(*f*) Analyzing and valuating shipments of cobalt and nickel oxides shipped by the various smelters, and on which a bounty is paid.

The following list will show the work done by the Laboratory:—

Gold.—Three hundred and seventy-eight samples were assayed for gold and reports issued. One hundred and twenty-seven of these were done for the Bureau and two hundred and fifty-one for the public.

Silver.—Seventy-one samples of silver were assayed for the public and forty-nine for the Bureau: one hundred and twenty in all. This does not accurately represent the work as a car lot is represented here by one sample.

Platinum.—Fifty-five samples—forty-eight for the Bureau and seven for the public. The method for assaying is given elsewhere in this Report.

Copper.—Forty-five samples—twelve for the Bureau and thirty-three for the public.

Iron Ores.—Eight samples were analyzed for iron. During the latter part of December a large number were analyzed for iron, phosphorus, sulphur, silica. ferrous iron, etc. These will appear in next year's report.

General.—Twenty-eight rock samples were submitted by the geologist of the Bureau for exhaustive analysis. One hundred and sixty-six other samples were received, including samples of feldspar, molybdenite, graphite, lead, zinc, etc. In carrying out this practical work only one assistant, T. E. Rothwell, was employed.

In addition to the work designated in this report the writer had charge of the mineral exhibit of the Ontario Bureau of Mines at the Canadian National Exhibition, Toronto. This entailed a large amount of work, and he desires to thank the mine owners and managers who so kindly loaned samples and in other ways contributed to the success of this exhibit.

Platinum Method.—During the year a decided increase in the platinum assays shows a continued interest by the public in this precious metal, which has increased enormously in value in recent years.

The method used in the chemical determination of platinum and allied metals is that outlined by A. M. Smoot, chief chemist of Ledoux & Company, New York, in the *Engineering and Mining Journal,* Vol. 99, pp. 700-701, April 17th, 1915, and reprinted by the United States Geological Survey.*

For the prospector and those with slight chemical equipment the identification of platinum and allied metals is not always certain. The following tests are believed to be most easily applied, and, if the material is carefully handled, they will give fairly reliable results.

Platinum has a colour ranging from silvery white to steel-gray, its shade depending on the quantity of impurities present. In some placer deposits the grains of platinum are coated with a dark film and somewhat resemble grains of ilmenite or magnetite, from which, however, they are separated by careful washing, as platinum has a specific gravity equal to or greater than gold, and so stays in the pan with the gold.

Platinum will not amalgamate with quicksilver alone, but will amalgamate if sodium is added. In ordinary quicksilver amalgamation the flakes of platinum float on the surface and can be removed. If sodium is used, the platinum may be separated from gold by agitating the amalgam with water until all the sodium is used up to form sodium hydroxide,

*Quotation from "The Production of Platinum and Allied Metals in 1914," by James M. Hill, U. S. Geological Survey.

when the platinum will come out on the surface of the amalgam, provided, of course, that it is sufficiently liquid.

Platinum has a hardness of 4 to 5, and can be scratched with a knife. It is so malleable that it can be pounded without heating into very thin sheets. It is infusable, cannot be run together as gold can, and is insoluble in all acids except aqua regia, a mixture of two parts hydrochloric (muriatic) acid and one part nitric acid. This solution (platinum chloride?) is yellow, but its colour is changed to deep red by the addition of metallic tin. From an aqua regia solution, potassium platinic chloride (K_2PtCl_6), a yellow crystalline precipitate is formed when potassium chloride (KCl) is added; or ammonium platinic chloride (NH_42PtCl_6) also yellow when ammonium chloride (NH_4Cl) is added. Both these precipitates are insoluble in alcohol, but are soluble in water, and may be reduced by heating, so that sponge platinum is left.

Radium.—Of the number of samples tested for radium only three showed signs of radio-activity. These were as follows:

1. Sample of euxenite submitted by Jas. A. Morrow, Maberley, Ontario.
2. Sample of euxenite from E. H. Wilson, Perth, Ont. This sample was obtained from near Maberley.

Euxenite is a dark mineral with a conchoidal fracture and brownish streak, containing niobium and tantalum, along with rare metals; yttrium and cerium in combination with iron and titanium, and it also contains some uranium.

3. Corundum concentrates submitted by the Provincial Geologist.

Samples are dealt with in order of their arrival. In every instance specimens and samples should be accompanied by statement specifying the precise locality from whence they were taken.

Crushed samples representing large quantities or samples less than five pounds weight may be sent by mail as third-class matter. Write your name and address plainly on each parcel. Send instructions, with money in payment of fees in a separate letter. Samples may be sent by express, charges prepaid. Sample bags addressed to this Laboratory for sending ore pulp by mail may be obtained free on application; also canvas bags for shipping.

Money in payment of fees, sent in by registered letter, post-office order, postal note, or express order, and made payable to the Provincial Assayer, must invariably accompany sample to insure prompt return of certificate, as no examination is commenced until the regulation fee is paid.

Address samples as follows:

Provincial Assay Office,
5 Queen's Park,
Toronto, Ont.

TARIFF OF FEES FOR ANALYSES AND ASSAYS

1. *Assays:*

Gold	$1 00
Silver	1 00
Gold and silver in one sample	1 50
Platinum	4 00
Gold and platinum in one sample	5 00
Gold by amalgamation	2 00

For the amalgamation assay for gold at least five pounds of ore must be sent.

2. *Iron Ores:*

Iron (metallic)	$1 00
Silica	1 50
Iron and insoluble residue	1 50
Ferrous oxide	2 00
Phosphorus	2 00
Sulphur	2 00
Iron, sulphur, phosphorus and insoluble	5 00
Manganese	2 00
Titanium	2 00
Complete analysis:—Ferrous oxide, ferric oxide, total metallic iron, silica, alumina, lime, magnesia, manganese, phosphorus, sulphur and titanium..	15 00

3. *Limestones, Dolomites, Marls, Clays, Shales:*

Determination of:

Insolubles	$1 00
Silica	1 50
Ferric iron	2 00
Ferrous iron	2 00
Alumina	2 00
Lime	1 50
Magnesia	1 50
Alkalies (combined)	5 00
Potash	4 00
Water (combined)	1 00
Moisture	0 50
Organic matter	1 00
Carbon dioxide	1 50
Sulphur	2 00
Phosphorus anhydride	2 00

4. *Examination of Clay, Shale, or Cement Rock for cement manufacture:*

Determination of silica, iron oxide, alumina, lime, magnesia, sulphuric anhydride and volatile matter $10 00

5. *Coal, Coke, Peat, etc.*

Determination of:

Moisture	$0 50
Volatile combustible	1 00
Fixed carbon	1 00
Ash	1 00
Sulphur	2 00
Phosphorus	2 00
Calorific value	5 00
Ultimate analysis	Price on application

6. *Mineral Waters* ..... Price on application

7. *Ores and Minerals:*

Determination of:

Alumina	$2 00
Antimony	3 00
Arsenic	3 00
Bismuth	3 00
Cadmium	3 00
Chromium	3 00
Cobalt	3 00
Copper	2 00
Gold	1 00
Ferrous oxide	2 00
Ferric oxide	2 00
Lead	2 00
Lime	1 50
Magnesia	1 50
Molybdenum	2 00
Manganese	2 00
Nickel	3 00
Silica	1 50
Water	1 00
Zinc	2 00

8. *Rocks, Complete Analysis* .....Prices on application

9. *Slags, Sand, etc.* .....Prices on application

10. *Identification of Minerals and Rocks not requiring Chemical Analysis* .....Free

Any analytical work not specified in this tariff will be undertaken on application to the Provincial Assayer.

The pulp of each sample is retained for future reference.

MINING ACCIDENTS IN ONTARIO IN 1915

By

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, E. A. Collins, Kingston; James Bartlett, Cobalt

General

During the year 1915 at the mines, metallurgical works, quarries, clay and gravel pits regulated by the Mining Act of Ontario there were 22 fatal accidents, causing the death of 22 men, as compared with 58 deaths in 1914 and 64 in 1913. Of these 17 occurred underground, a decrease of 12 as compared with the preceding year. The fatal accidents took place in mines operated by 11 different companies. Only one fatality occurred at metallurgical works, as compared with 5 in 1914 and 11 in 1913.

There were no fatalities in quarries, clay pits and gravel pits governed by the Ontario Mining Act. Four farmers in different parts of the province were killed by falls of sand and gravel. These accidents were duly investigated, and it was found that in three cases gravel was being hauled by the farmers in performance of their annual statute labour on the roads; in the fourth case the gravel was to be used in building a concrete silo. As this Department has no jurisdiction over such works or such labour, the accidents are not included in these statistics; but they emphasize the danger even in small gravel pits, a danger as a rule totally unrecognized by the man not familiar with such operations.

The decrease, compared with the preceding year, in accidents at quarries, clay and gravel pits is no doubt largely due to the fact that excavating operations were greatly curtailed during 1915.

The tables of accidents at the metallurgical works and quarries are separated in this report from accidents at mines. For this tabulation the clay and gravel pits are grouped under the heading, Quarries.

The total number of serious accidents in and about the mines of Ontario reported to the Bureau of Mines in 1915 was 424, resulting in 21 deaths and injuries to 415 persons. In the non-fatal accidents, 305 men were injured underground and 110 above. At metallurgical works there were 71 accidents, resulting in one death and injuries to 70 persons. Eleven non-fatal accidents were reported from quarries.

In accordance with the Mining Act inquests were held on all fatal accidents and attended by one of the Inspectors.

Table of Accidents

	1914		1915	
	Killed.	Injured.	Killed.	Injured.
MINES:—				
No. killed underground	29		17	
No. " surface	9		4	
No. injured underground		251		305
No. " surface		77		110
METALLURGICAL WORKS:—				
No. killed	5		1	
No. injured		101		70
QUARRIES:—				
No. killed	15			
No. injured		16		11
Totals	58	445	22	496

The fatal accidents occurring in the mines were divided amongst the several districts as follows:—

	1914.	1915.
Gold mines of Porcupine and Kirkland lake	12	3
Silver mines of Cobalt and adjacent districts	11	6
Nickel-copper mines of Sudbury	9	11
Iron mines of Michipicoten	4	0
Iron pyrites mine, western Ontario	1	0
Eastern Ontario	1	1
	38	21

By months the mining fatalities occurred as follows:—

Month.	1914.	1915.
January	6	0
February	5	3
March	7	0
April	7	3
May	5	0
June	8	1
July	4	2
August	5	3
September	2	3
October	3	3
November	4	1
December	2	2
	58	21

Analysis of Fatalities at Mines

Cause.	1914	1915
	Per cent.	Per cent.
Falls of ground	7.9	4.8
Shaft accidents	26.3	23.8
Explosives	26.3	33.3
Miscellaneous (underground)	15.8	23.8
Surface	23.7	14.3

Table of Fatal Accidents in Mines, Metallurgical Works and Quarries, 1901 to 1915

—	Persons killed at metallurgical works and mines.	Persons employed at metallurgical works and producing mines.	Persons employed at non-producing mines (estimated).	Total persons employed.	Fatal accidents per 1,000 employed.
1901.....	13	4,135	550	4,685	2.77
1902.....	10	4,426	450	4,876	2.05
1903.....	7	3,499	400	3,899	1.79
1904.....	7	3,475	400	3,875	1.80
1905.....	9	4,415	500	4,915	1.83
1906.....	11	5,017	750	5,767	1.90
1907.....	22	6,305	1,140	7,445	2.93
1908.....	47	7,435	1,750	9,185	5.11
1909.....	49	8,505	2,000	10,505	4.66
1910.....	48	10,862	2,000	12,862	3.73
1911.....	49	12,543	2,000	14,543	3.37
1912.....	43	13,108	2,000	15,108	2.84
1913.....	64	14,293	2,000	16,293	3.93
1914.....	58	14,361	1,500	15,861	3.6
1915.....	22	13,114	1,500	14,614	1.50
Totals ..	459	125,493	18,940	144,433	3.18

As will be seen from the above table the fatal accidents per 1,000 employed in 1915 is the lowest of which there is any record in Ontario mines.

Cause and Place of Fatalities in Mines

The following schedule shows the cause and place of the fatalities in 1915 compared with 1914:—

BELOW GROUND

	1914.	1915.
Falls of ground	3	1
	— 3	— 1
Shaft accidents:—		
Struck by cage	0	1
Staging in shaft breaking	1	0
Falling down shaft	2	1
Objects falling down shaft	2	0
Falling from bucket or skip	2	1
Attempting to get on and off skip or cage in motion	1	0
Run over by skip	1	1
Killed in cage while gassed	1	0
Runaway car	0	1
	—10	— 5

	1914.	1915.
Explosive accidents:—		
Premature explosion while loading or lighting holes	5	0
Drilling into bottom of old or missed holes	1	2
Asphyxiation from gases from explosives and falling	2	1
Picking or putting bar into old hole containing explosive	1	1
Delayed explosion while sandblasting	1	0
Explosion in blacksmith shop (above ground)	0	1
Explosion in magazine	0	1
Walked into blast	0	1
	10	7
Miscellaneous accidents:—		
Falling down winze	2	1
Falling down stope	1	3
Struck or buried by ore	2	0
Crushed between cars	0	1
Scaling	1	0
	6	5
ABOVE GROUND.		
Slide of surface material	0	1
Struck by falling objects	1	0
Electrocuted	0	1
Killed by fall	3	0
Caught by machinery	1	1
Team running away	1	0
Drowned	2	0
Boiler explosion	1	0
	9	3
Totals	38	21

The occupation and nationality of men killed in or about the mines are set out in the following table:—

Occupation.	English-speaking.	Finn.	Italian.	Austrian.	Roumanian.	Bulgarian.	Total.
Drill runner	1	1	1	1	.....	.....	4
Drill helper	1	1	.....	1	1	.....	4
Trammer	.....	.....	1	1	.....	1	3
Chute blaster	.....	.....	.....	1	.....	.....	1
Foreman	1	.....	.....	.....	.....	.....	1
Mule driver	1	.....	.....	.....	.....	.....	1
Timberman	1	.....	.....	.....	.....	.....	1
Electrician	1	.....	.....	.....	.....	.....	1
Blockholer	1	.....	.....	1	.....	.....	2
Surveyor	1	.....	.....	.....	.....	.....	1
Pumpman	1	.....	.....	.....	.....	.....	1
Blacksmith	1	.....	.....	.....	.....	.....	1
Totals	10	2	2	5	1	1	21

The ages of the men killed in the mines were as follows:—

17-20	21-25	26-30	31-35	36-40	41-45	46-50	56-60	Total.
3	5	4	3	1	1	3	1	21

Cause and Place of Non-Fatal Accidents at Mines

The following schedule shows the cause and place of the non-fatal accidents in 1915 at the mines and the number injured:—

UNDER GROUND

Falls of ground	9	
		9
Shaft accidents:—		
Cage accidents	8	
Falling part way down shaft	7	
Objects falling down shaft	9	
Miscellaneous	0	
		24
Explosives:—		
Drilling into old or missed holes	7	
Picking into explosives	3	
Premature explosion	9	
		19

MISCELLANEOUS ACCIDENTS

Falling down stopes, raises, winzes, chutes or man-ways	11	
Jammed by cars, skips, buckets or pieces of rock or ore	48	
Scaling	14	
Foreign material in eyes	21	
Injured at chutes	69	
Flying rock	3	
Rock rolling down pile	12	
Caught by drill	28	
Falling objects	8	
Falling from staging	13	
Miscellaneous	26	
		253

SURFACE

Falling from elevated places	14	
Caught by machinery	33	
Burned by electric wire	1	
Falling objects	14	
Burned	7	
Foreign material in eyes	4	
Slipped on ice	6	
Miscellaneous	31	
		110
		415

The occupation and nationality of the men injured in or about the mines follows herewith:—

Occupation.	English-speaking.	Italian.	Austrian.	Finn.	Russian.	Pole.	Swede.	Roumanian.	Bulgarian.	Spaniard.	German.	Serbian.	
Trammer	13	40	22	11	26	5	2	5	6	2	1	1	134
Drill runner	30	18	16	19	3	4	4	1	....	....	....	....	95
Labourer	11	20	6	....	5	1	....	....	....	....	....	....	43
Drill helper	14	7	2	3	2	....	1	1	....	....	....	....	30
Timberman	5	....	....	8	....	....	....	....	....	....	....	....	13
Machinist	8	3	....	....	....	....	....	....	....	....	....	....	11
Carpenter	9	1	....	....	....	....	1	....	....	....	....	....	11
Millman	9	1	1	....	....	....	....	....	....	....	....	....	11
Blacksmith	7	1	....	....	....	....	....	....	....	....	....	....	8
Cage tender	5	1	1	1	....	....	....	....	....	....	....	....	8
Ore sorter	4	2	1	....	1	....	....	....	....	....	....	....	8
Foreman	7	....	....	....	....	....	....	....	....	....	....	....	7
Blaster	....	4	1	....	....	....	1	....	1	....	....	....	7
Scaler	1	....	....	3	....	1	....	....	....	....	....	....	5
Teamster	5	....	....	....	....	....	....	....	....	....	....	....	5
Blockholer	1	1	1	....	....	....	1	....	....	....	....	....	4
Electrician	3	....	....	....	....	....	....	....	....	....	....	....	3
Crusherman	1	....	....	....	1	....	....	....	....	....	....	....	2
Surveyor	2	....	....	....	....	....	....	....	....	....	....	....	2
Nipper	....	....	1	....	....	....	1	....	....	....	....	....	2
Deckman	1	....	....	....	....	....	....	....	....	....	....	....	1
Assayer	1	....	....	....	....	....	....	....	....	....	....	....	1
Pumpman	1	....	....	....	....	....	....	....	....	....	....	....	1
Hoistman	1	....	....	....	....	....	....	....	....	....	....	....	1
Sculler	....	....	....	....	1	....	....	....	....	....	....	....	1
Trackman	1	....	....	....	....	....	....	....	....	....	....	....	1
Totals	140	99	52	45	39	11	11	7	7	2	1	1	415

Falls of Ground

Only one man was killed from this cause during 1915, and in this case the deceased, an Austrian, had been warned by the man working on the opposite shift at the same part of the stope to keep away from the particular spot where the accident occurred. The shift boss, making his rounds, found the deceased, who was a blockholer, working under this bad ground and ordered him to stop drilling and to scale, but before he could remove his drill and hose the ground fell.

Shaft Accidents

Five men were killed in shaft accidents as compared with 10 in 1914. In the case of the Acme accident on April 9th the deceased, an Austrian, was leaning over the guard rail looking for the cage when he was struck. All guard rails at shaft openings on the Acme, Hollinger and Millerton properties are now set out from the shaft a distance of about 18 inches.

The accident at No. 20 winze in the O'Brien mine on February 23rd, when a timberman named Lennox was killed, was due to riding a bucket against orders and to an unsuitable hoist. The hoist was equipped with a foot brake. When Lennox

got in the bucket the friction loosened and, before the hoistman could get to the hoist, the bucket dropped to the bottom of the winze.

A Roumanian drill helper, while riding the skip in an incline shaft at the Levack mine on July 15th, was caught by the station timbers and swept off the skip. Four men were on the skip, and the skiptender gave the signal to hoist while the shift boss was on the station. It appears therefore that the shift boss was not very strict regarding infringements of this provision of the Mining Act.

A Finn who was getting a bucket of water from the sump in the Mount Nickel shaft was struck by the descending skip and killed.

A mule driver on the level from the bottom of the incline shaft to the Dome mill was killed when a loaded car broke away at the top of the incline and, keeping the track, ran out on the level and struck the car being hauled away. The last was the only one of the shaft accidents not due to carelessness or an infringement of the Mining Act.

Accidents from Explosives

As in other years the percentage of fatal accidents due to explosives is higher than from any other cause, being 33.3 per cent. in 1915, 26.3 per cent. in 1914 and 31.1 per cent. in 1913. Seven men were killed in explosive accidents and 19 injured.

Two of the fatal accidents were directly due to infringements of the Mining Act. At the Craigmont mine on February 18th dynamite was being thawed beside the boiler in a building used as a blacksmith shop and boiler house when an explosion occurred, resulting in the death of the blacksmith's helper. The cause of the explosion of four boxes of dynamite in a temporary magazine at the Creighton mine is unknown, but the chute blaster in charge of this powder was known to be in the magazine with an open carbide lamp when the accident occurred.

In the Kerr Lake accident Eldridge, the mine surveyor, was piloting a visitor, Foote, through the mine when they walked into a blast. Both men were instantly killed.

Sauve, who was killed at the Nipissing, fell while going up into a raise shortly after blasting. He was probably overcome by gas, as he was on his way up to learn why the air was not blowing.

Three fatalities were due to unexploded powder in the bottom of holes; in two of these cases, the Worthington and Cobalt Comet, No. 6 detonators had been used. To ensure complete detonation No. 8 caps should be used, and it is unfortunate that any of the No. 6 are on the market.

Miscellaneous Accidents Underground

Five men were killed in accidents that come under this heading. These accidents occurred in the nickel mines of the Sudbury district, and all were in connection with the mining and handling of large tonnages; one through falling down an ore pass, one by being crushed between two ore cars and three by falling off benches. In connection with the accident at the Garson mine, the deceased had not a life line on as required by the rules of the company. His helper's life was saved by the observance of this precaution.

Surface Accidents

Four men were killed in surface accidents, including the fatality at Craigmont while thawing powder in the blacksmith shop which is included under the heading of explosive accidents. The practice of storing electrical supplies in the transformer house resulted in the death of an electrician at the Acme mine, and an exposed set screw in the pump house at the Temiskaming mine resulted in a fatal accident.

Prosecutions

Before Thos. M. Wilson, J.P., at South Porcupine on June 25th L. Mazzutto, an Italian foreman at the Dome mines, was fined $100 and costs for violating rule 98, sec. 164, of the Mining Act. Mazzutto's offence was that on June 15th he sent some men up in the skip without waiting for the skip tender to give the necessary signal.

Rules of Canadian Copper Company

At the mines of the Canadian Copper Company the following methods, as explained by Superintendent J. C. Nicholls, are required to be followed in dealing with winding ropes:—A daily examination of the winding ropes and attachments thereof, to the drums and to the cages, skips and other means of conveyance, the brakes and depth indicators, the cages, skips or other means of conveyance, and any safety catches attached thereto, and the pulley wheels and all and every external part of the winding arrangements, upon the ropes or working on which the safety of persons depend.

A monthly examination at least of the structure of the winding rope, with a view of ascertaining the amount of deterioration thereof. For the purpose of this examination the rope must be cleansed at places selected by the mechanical engineer, who notes any reduction in the circumference of and the proportion of wear in the ropes.

At least once in six months the winding rope is recapped, a portion thereof, not less than seven (7) feet in length, being at the same time cut off at the lower end.

The portion of the rope so cut off shall have ends adequately fastened with binding wire to prevent disturbance of the strands and shall be sent to a reputable testing laboratory and a certificate showing the result shall be furnished to the owner.

At the periodical recapping of the winding rope, the connection between the rope and the cage, skips, or other means of conveyance is annealed.

All new ropes purchased must be accompanied by a certificate from the manufacturer showing the amount of breaking load, as ascertained by actual test.

A winding rope newly put on and the connecting attachments between the rope and the cage, skips or other means of conveyance must be carefully examined by mechanical engineer, and must not be used for the ordinary transport of persons in any shaft or winze until after two complete trips up and down the working portion of such shaft or winze, the cage, skip or other means of conveyance attached thereto

bearing its authorized load. The result of the above examination must be immediately recorded in a book.

In case of an overwind or skip or cage derailed, the ropes and all attachments are examined, and must not be used for raising or lowering persons until conveyance has been run at least two (2) complete trips up and down the working portion of the shaft.

No winding rope for raising and lowering persons shall be used when the breaking load at any point therein has become reduced to less than six times the maximum working load. The maximum working load shall include the weight of the rope in the shaft when the cage, skip or other means of conveyance is at the correct working point and the weight of such conveyance with its contained load.

During hard frost it has been found necessary to instal scraper, to prevent ice building up in groove of pulley wheels on headgear.

Signal System of Canadian Copper Co.

The aim in laying out a signal system for the mines was to get something which should combine safety and efficiency.

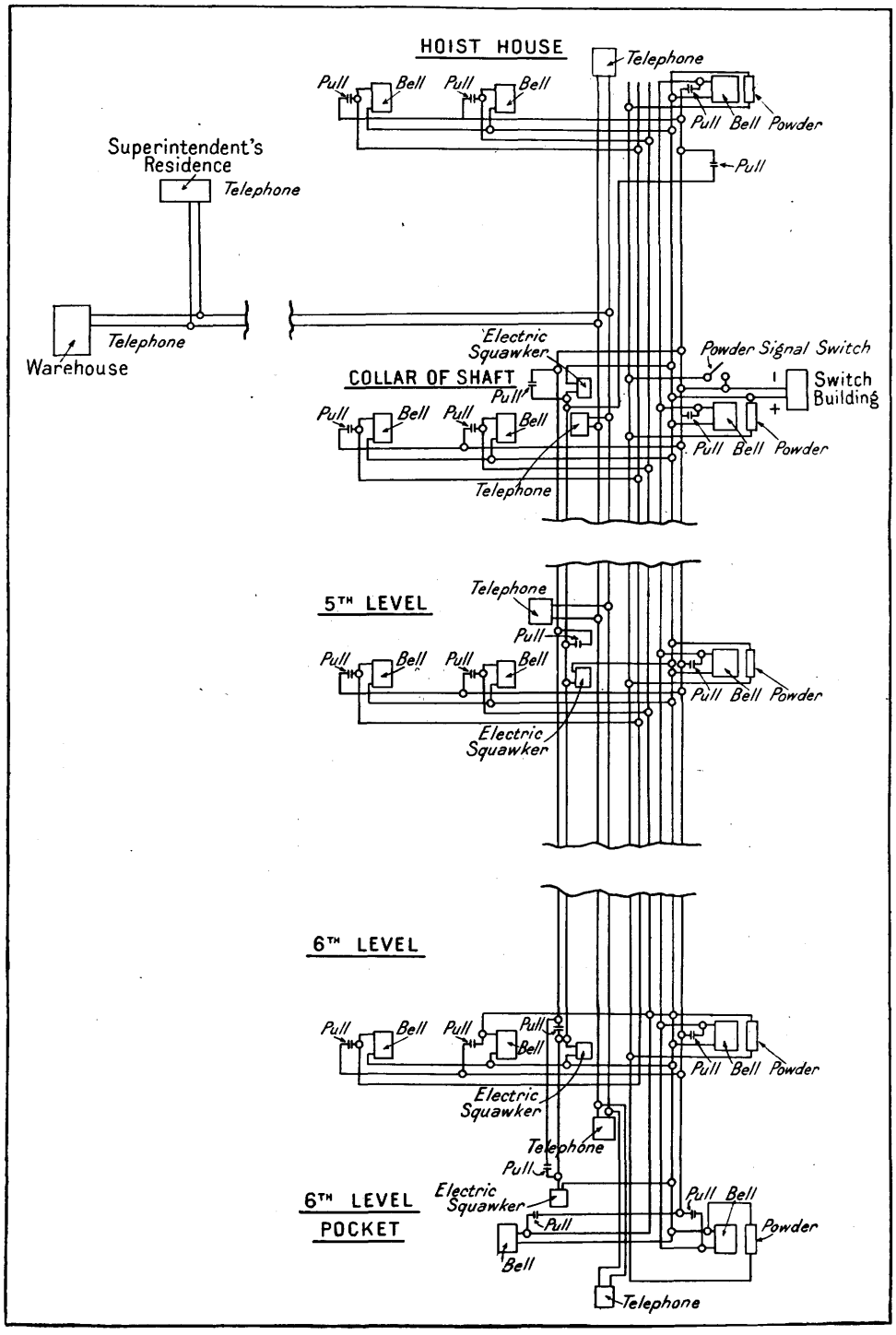
The code of signals adopted was started with the signals prescribed by the Mining Act, with the addition of other signals to meet our needs. In all auxiliary signals the one, two, or three bells were not used—these being kept solely for the use given in the Mining Act. Cases have been known where a repetition of the one, two, or three bell signals in level, or other auxiliary signals, has led to serious hoisting accidents.

The hoistman, after receiving signals to move men, waits for ten seconds before moving the cage. In case he is not able to move the hoist within one minute after receiving the signal he awaits a fresh signal.

The system is the return bell electric system. When a signal is given at any point, this rings signal bells for that compartment at the hoist, collar, and all stations. The bells for each compartment have different tones, so that it is easy to distinguish in which compartment signals are being given. When the hoistman receives a signal, he immediately repeats it, so that the man giving the original signal knows if his signal is received correctly, and he has then time to give a correcting signal if not correctly answered. In hoisting men three distinct signals are given: First, the three bells, indicating men to be moved; second, the signal for the level to which the cage is to be moved; and third, the one or two bell signal, signifying that the cage is to be moved. The hoistman repeats each of these three sets of signals, so that there is no chance of a misunderstanding. It would appear that the code of signals means a large number of bells being rung and might be confusing, but this is not a fact, as the men soon get used to it. Also as a quick ringing bell is part of the system, the time consumed is not noticeable.

When explosives are being sent into the mine, the powderman closes the powder signal switch, which throws on a red light at the hoist in the engine room, shaft collar and all levels.

In addition to the bells there is a buzzer at each level and the collar of the shaft. This does not signal the hoistman but is used as a call for the cage. This signal



Signal System, No. 2 Shaft, Creighton Mine.

when heard at any level indicates to the cage tender, the level at which the cage is wanted. This buzzer having a distinct tone is not confused with the bell signals.

Also there is a telephone system connecting all levels, the hoist house, the collar and thence to various offices on the surface.

Near the collar of the shaft is located a brick junction house where all cables leading into the mine are led through switches, so that any circuit can be cut off.

The cable used for signalling has twelve conductors of No. 10 wire, rubber-covered, taped, jute-wound, lead-sheathed, steel-wire wound and weather-proofed. At each level this is led into a water-tight junction box for distribution to the various signals at that level. The distribution from the junction box to the signals is usually by means of weather-proof wire led into conduit.

The pulls are specially designed and are waterproof. The bells are single stroke, the striking hammer being a soft iron plunger set loosely in a solenoid. The current used to operate the bell is alternating current of 110 volts and a frequency of 25 cycles. The single stroke bell admits of fast signalling, and there is less chance of confusion than there would be with a vibrating bell.

During the time that this system has been in use, there have been no accidents due to signalling, and very few delays attributable to the derangement of the system.

Accidents at Metallurgical Works and Quarries

The metallurgical works which come under the Mining Act of Ontario include blast furnaces, copper-nickel smelters and converter plants, silver smelters and acid plants.

At these works during 1915, there were 71 accidents which were reported to this department, only one of which was fatal. In the preceding year five men were killed and 101 injured.

The fatal accident occurred in the roast yards of the Mond Nickel Company at Coniston. An Italian labourer was killed while riding on the locomotive crane.

Eleven accidents were reported from the quarries during the year, none of which were fatal.

The following schedule shows the cause of the non-fatal accidents in 1915, at the metallurgical works, and the number injured:—

Burned	13
Falling objects	7
Falling from elevated places	5
Slipped and fell	7
Caught by machinery	11
Injured by cars	11
Crushed between two objects	4
Cut by slag, matte, etc.	5
Struck by hammer	1
Foreign substance in eye	2
Miscellaneous	4
Total	70

In the subjoined table is given the occupation and nationality of the men injured in metallurgical works.

Occupation.	English-speaking.	Italian.	Russian.	Austrian.	Belgian.	Finn.	Swede.	Hungarian.	Roumanian.	Total.
Stove tender	1									1
Engineer	1									1
Furnace keeper		1						1		2
Labourer	5	13		10				1	1	30
Mechanic	7				1					8
Fireman		1								1
Railway conductor	1									1
Baleman		1		3						4
Brakeman	3									3
Tapper			1	1						2
Carpenter	6									6
Electrician	1									1
Teamster						1				1
Nitric runner	1									1
Ladle liner		1					1			2
Hooker-on	1									1
Chute man	1									1
Scrapper		1								1
Skimmer	2									2
Converterman	1									1
Total	31	18	1	14	1	1	1	2	1	70

Table of Fatal Accidents in

Number.	Date 1915	Name of Mine.	Name of Owner.	Name of Deceased.	Occupation of Deceased.
1	April 9	Acme	Acme Gold Mines, Ltd..	G. Buklajczruk ...	Trammer .....
2	" 23	do	do do ..	H. Lyne	Electrician ....
3	Aug. 19	Creighton	Canadian Copper Co. ...	W. Cristoff	Trammer .....
4	" 20	No. 2	do do ..	P. L. Walker	Drill helper ...
5	Sept. 3	Creighton	do do ..	N. Vartiniuk	Chute blaster ..
6	Oct. 12	do	do do ..	M. McCarthy	Blockholer ....
7	" 12	do	do do ..	B. Benbentento ...	Trammer .....
8	" 14	do	do do ..	H. Romanka	Blockholer ....
9	Dec. 16	Crean Hill	do do ..	P. Stasiuk	Drill helper ...
10	April 21	Drummond	Cobalt Comet Mines, Ltd	C. Peterson	Drill runner ...
11	Dec. 20	do	do do ..	M. McFarland	Foreman .....
12	Sept. 25	Dome	Dome Mines Co.	A. Maurice	Mule driver ...
13	June 25	Kerr Lake	Kerr Lake Mining Co...	W. Eldredge	Surveyor .....
14	Feb. 18	Craigmont	Manufacturers Corundum Co.	M. Cannon	Blacksmith ...
15	July 15	Levack	Mond Nickel Co.	G. Policiuk	Drill helper ...
16	Sept. 8	Garson	do do ..	G. Parolin	Drill runner ...
17	Nov. 6	Worthington	do do ..	G. Zakula	Drill runner ...
18	Feb. 18	Nipissing	Nipissing Mining Co. ...	E. Sauve	Drill runner ...
19	" 23	O'Brien	M. J. O'Brien	W. Lennox	Timberman ...
20	July 15	Mount Nickel	Sudbury Leasing & Development Co.	H. Poutanen	Drill helper ...
21	Aug. 4	Temiskaming	Temiskaming Mining Co.	H. Savage	Pumpman .....

Table of Fatal Accidents

Number.	Date of Accident.	Name of Works.	Name of Owner.	Name of Deceased.	Occupation of Deceased.
1	April 2..	Roast yards ...	Mond Nickel Co.	G. Trocatto ...	Labourer .....

or about the Mines, 1915.

Nationality of Deceased.	Age.	Married or single.	Below ground.	Above ground.	Cause of Accident.
Austrian	48	M	1	.....	Leaned over guard rail to look for cage and was struck by descending cage.
English-speaking	28	S	.....	1	Electrocuted in transformer house.
Bulgarian	33	M	1	.....	Crushed between two cars and bowel ruptured. Died August 22nd.
English-speaking	24	M	1	.....	Fell from bench into stope. Died Aug 21st.
Austrian	20	S	1	.....	In underground magazine with lighted carbide lamp when explosion occurred.
English-speaking	37	S	1	.....	Drilled into explosive, while blockholing in stope.
Italian	26	S	1	.....	Fell down ore pass with timber truck.
Austrian	20	S	1	.....	Fall of ground in stope.
Austrian	21	S	1	.....	Fell off bench into stope.
Finn	49	M	.....	1	Struck by slide of surface material.
English-speaking	49	M	1	.....	While sampling, pick struck explosive.
English-speaking	23	M	1	.....	Loaded car broke away at top of incline.
English-speaking	28	S	1	.....	Walked into blast.
English-speaking	57	M	.....	1	Thawing powder beside boiler in blacksmith shed.
Roumanian	21	S	1	.....	Riding skip with material.
Italian	30	S	1	.....	Drilling bench, fell into stope. Deceased had not life line on.
Austrian	31	M	1	.....	Drilled into explosive.
English-speaking	34	M	1	.....	Overcome by gas in raise, and fell.
English-speaking	42	M	1	.....	Got on bucket when hoistman was away from hoist, friction loosened and bucket dropped to bottom of shaft.
Finn	24	M	1	.....	Struck by skip while in sump for water. Died July 21st.
English-speaking	20	S	.....	1	Caught by setscrew and drawn into gears of pump.

at Metallurgical Works, 1915.

Nationality of Deceased.	Age.	Married or single.	Nature and Cause of Accident.
Italian	20	S	Crushed while riding on locomotive crane.

MINES OF ONTARIO

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, E. A. Collins, Kingston; J. G. McMillan, Cobalt; Jas. Bartlett, Sudbury.

I.—NORTHWESTERN ONTARIO

Bannerman and Horne Quarries.—Messrs. R. C. Bannerman and Wm. Horne of 126 Polson Avenue, Winnipeg, did not work their quarry at Ignace in 1915, but opened up another granite quarry at Butler, a few miles west of Ignace. They employed ten men part of the summer cutting paving blocks. The owners report that the granite in this new quarry is particularly adapted for paving and building purposes.

Big Master, Jubilee and Laurentian.—The Dominion Reduction Company of Cobalt unwatered the above-mentioned mines in the Wabigoon locality in January, 1916, and completed sampling in the following month. It is understood that the results of the examination were unsatisfactory and that the options were relinquished.

Cameron Island Mine.—The Cameron Island Syndicate, Limited, started work on June 1st, 1915, at the mine situated on Cameron Island (Island S. 170) near the centre of Shoal Lake, District of Kenora. This property has been idle since July, 1912. At the time of inspection (Oct. 11, 1915), the mine was unwatered but no underground work was being done, the thirteen men employed all being engaged in remodelling the mill.

The mine has a 7 foot by 12 foot shaft, 132 feet deep with an inclination of approximately 80 degrees. Levels have been driven at 62 feet and 127 feet. On the first level 32 feet of drifting has been done to the north and 48 feet to the south of the shaft. On the second level a 268 foot drift extends to the south and 140 feet of crosscutting has been done from it. Above this drift a small stope has been worked to a height of 20 feet. On the east side of the island an adit has been driven due west 64 feet.

The ten stamps and two Frue vanners which the mill formerly contained have been discarded and the machinery arranged as described below. A brick obtained from a trial run of 5 tons gave, when refined, $47.81 in gold and over 6 ounces of silver. The ore is fed through a Farrell jaw crusher with an opening about 7 inches by 10 inches. From this it passes to two Forsythe pulverizers. A bucket elevator then carries the material to a cylindrical 40-mesh wire screen, 18 feet in diameter by 12 feet long. Oversize from this screen returns to No. 2 pulverizer. The undersize passes through a bin to a rotary roasting kiln placed outside the mill. The kiln discharges the roasted material to a cement floor, where water is added and the whole elevated by a maple screw conveyor to a circular wooden tank fitted with a revolving rake. Thence it passes over two amalgamating plates. It is intended to put in Wilfley tables to concentrate the tailings from these plates.

The power plant consists of an 80-h.p. r.t. boiler, with a 35-h.p. locomotive type in reserve, a 360 c.f. Ingersoll-Sergeant air compressor, a 12-h.p. engine to drive the rotary kiln, and a 50-h.p. Corliss engine to drive the remainder of the mill machinery.

The head office is at Hamilton, Ont.; mine office address is Cameron Island, P.O., via Kenora, Ont. The officials of the company are:—

President and Managing Director—Donald M. Cameron, Hamilton.
Vice-President—J. G. Palmer, Toronto.
Secretary-Treasurer—Mrs. Lucy O. Cameron, Hamilton.
Directors—Frank Grew, Toronto.
Alfred Rolph, Toronto.
Dr. J. M. Jury, St. Catherines.

Donald M. Cameron is in charge of the work on the property.

Hewitson and Johnston Claims.—These claims are situated about four miles west of Mine Centre and about half a mile from the track of the Canadian Northern Railway. The claims were located on June 5th, 1916, and by August 5th two cars of copper ore, said to be run about eight per cent. copper, had been shipped to the Trail Smelter, B.C.

The ore body is said to be 75 ft. wide and has been exposed over a length of 340 feet. It occurs in a schist formation. Since first located a party of six men have been working on the property mining out the pockets of high grade ore.

Intercities Quarries.—The trap quarry at Port Arthur owned by the Intercities Quarries Company, Limited, was not worked in 1915.

Mather and Beveridge Soapstone Claims.—Shipments of soapstone were made in 1915 from a deposit on an unpatented mining claim owned by Mather and Beveridge, and situated on Pipestone portage, near Pipestone bay, Lake of the Woods. The material was shipped to the Dryden Timber and Power Co., Dryden, Ont., for lining soda-smelting furnaces. It is used in blocks 18 inches by 12 inches by 8 inches.

Northern Pyrites Mine.—The Northern Pyrites Company, controlled by the General Chemical Company of New York, worked the pyrites mine at Northpines, Ont., to capacity in 1915 and shipped approximately 95,000 tons—a larger quantity than in any previous year. In order to take advantage of the remarkable demand for pyrites, energy was concentrated on increased production with the existing equipment. Consequently the greater part of the proposed programme of alterations outlined in the 24th Annual Report of the Bureau of Mines was deferred until the close of navigation in 1915. Active construction was then begun.

A new power and engine-house is now being built of steel and hollow tile. This measures 46 feet, by 124 feet and will contain the following machinery:—

Two Ingersoll-Rand, cross-compound air compressors, Class R.R. 3, with cylinders 20 inches and 20 inches by 18 inches. Each is to have a capacity of 1046 c.f. of free air per minute at 160 r.p.m.

One Corliss tandem engine, 150-h.p., with cylinders 22 inches and 12 inches by 42 inches.

A battery of five return tubular boilers—four 100-h.p. and one 125-h.p. These will be fitted with Dutch oven furnaces. Forced draught, furnished by turbo-blowers, will be used to burn 75 per cent. anthracite screenings and 25 per cent. bituminous coal.

The mine is served by two shafts:—No. 1, 242 feet deep, is vertical for 145 feet and at 60 degrees for the remainder of the distance; it is used only for handling steel and timber. No. 2 shaft is 376 feet deep and is inclined at 59 degrees for the first 320 feet and at 55 degrees for the remaining 56 feet. No. 2 is the main working shaft and from it four levels have been opened at 68, 130, 240 and 340 feet respectively.

The orebody has proved to be from 30 to 70 feet in width and is worked by a shrinkage method in stopes 100 to 150 feet long; 30-foot pillars are left between stopes. Above the first level no stoping has been done. On the second level three stopes west of the shaft have been exhausted and three others are now being worked. East of the shaft five have been opened. On the third level west of the shaft two stopes are worked out and two are being worked, while east of the shaft one stope is being mined and four are being developed. On the fourth level drifting has been done to 162 feet east and 164 feet west of the shaft.

H. V. Smythe is superintendent. About 135 men are employed.

Olympia Mine.—The Olympia gold mine is situated on Claim M. 11, on Hell-diver bay, Shoal lake, District of Kenora. The mine is owned by the Olympia Gold Mining Co., Limited. The mill was started on June 23, 1915, and was expected to close down about the end of October.

There are five prospect shafts on the property—110, 75, 70, 32 and 25 feet deep. Three tunnels also have been driven—one near the mill is 125 feet long and connected with the 70-foot shaft; the second is 40 feet long; the third measures 460 feet and stoping has been carried to surface in two places, one connection being near the inside end. At the time of inspection stoping by means of hand-drills was in progress in the last-mentioned tunnel.

The mill contains a 7 inch by 10 inch Blake crusher, 5 Allis-Chalmers stamps, 5 Jenckes stamps, amalgamating plates and two locomotive type boilers, 35 and 60 h.p. The officers of the company are:—President and treasurer, Franklin Floete, Spencer, Iowa; secretary and manager, George H. Vernon, St. Paul, Minn.; foreman, Emil Hubner, Kenora. The head office is at 973 Hague Ave., St. Paul, Minn. Seven men are employed.

St. Anthony Mine.—The Kerr Lake Mining Company of Cobalt sampled the St. Anthony mine on Sturgeon lake during the summer of 1915 and began work under an option in October.

The mine can now be reached by taking the canoe route from Wako, on the Fort William-Graham branch of the G.T.P. Ry., or by taking a four-mile road south from Bucke station, on the National Transcontinental Railway, to Trapper's Cabin. The latter point is on the north bay of Sturgeon lake and is nine miles from the mine.

The mine has been described in previous reports of the Bureau of Mines.

M. C. H. Little is superintendent and Duncan McPhail mine foreman.

II.—SUDBURY, NORTH SHORE AND MICHIPICOTEN

Algoma Steel Corporation

Helen.—The Helen mine of the Algoma Steel Corporation was worked continuously in 1915. During the year the shipments were as follows:—93,356 tons of hematite, about 7,000 tons of pyrite concentrates, and 38,000 tons of hematite tailings. The hematite came from the 6th, 7th and 8th levels. On the 6th level a body of pyrite was developed at the eastern end of the mine. The Wilfley table plant was started on June 1st on the concentration of this pyrite. The hematite tailings, which were shipped to Sault Ste. Marie, Ont., to be roasted by the Greenawalt process, came from a wash-plant operated at this mine a few years ago. They averaged 58 per cent. iron and 2½ per cent. sulphur.

One hundred and twenty-five men are employed under superintendent G. R. McLaren.

Magpie.—The Magpie mine and roasting plant of the Algoma Steel Corporation were started up on May 16th, 1915. Both had been closed down since Oct. 31st, 1914, on account of conditions due to the war. The production of roasted siderite for the year 1915 amounted to 129,722 tons.

On the second level all of the stopes are now developed. On the third level the orebody has been drifted on for a distance of 180 feet east and 180 feet west of the station.

A. Hasselbring is general superintendent; John M. Knote, roast plant superintendent; and Roland Irwin, mine captain. About 225 men are employed; of these 11 are in the roast plant and coal-grinding departments.

Canadian Copper Company

Mines operated by the Canadian Copper Company shipped 940,338 tons of nickel-copper ore to the Copper Cliff smelter in 1915. This ore came from the Creighton, Crean Hill, No. 2 and Vermilion mines, and is by far the largest production in the history of the company.

The officials of the company are:—

President, A. D. Miles.
General Superintendent, J. L. Agnew.
Superintendent of Mines, J. C. Nichols.
Assistant Superintendent of Mines, J. P. Hussey.
Chief Engineer, E. H. Jones.
Chief Metallurgist, J. W. Rawlins.
Safety Engineer, E. T. Corkill.

Canadian Copper Company Smelter.—At the beginning of 1915 only four out of the six furnaces at the Copper Cliff Smelter were in operation. A fifth was started on January 10th, and the sixth on February 8th. In August a new furnace, No. 7, was blown in. This furnace is deeper than the old one and is 25 ft. 6 inches by 50 inches. The older furnaces are now being made 3 feet 6 inches deeper and the settlers lowered to conform with this alteration. There were 865,169 tons of

ore smelted in 1915. All smelter employees are now on an eight-hour basis. W. Kent is smelter superintendent.

Crean Hill.—The Crean Hill mine of the Canadian Copper Company, which was closed in August, 1914, was started again in February, 1915. Shipments for 1915 amounted to 104,550 tons of ore. This came from the sides of the open-pit above the second level, from the 5th and 7th level floors, which were removed, and from the 8th level stope.

The shaft is now 915 feet deep. It is being made of 4-compartment size throughout. Formerly it consisted of four compartments to the 6th level and three below this point. The 9th level has been opened at 900 feet.

A new transformer house has been completed.

About 180 men were employed during the year under superintendent Charles Collins.

Creighton.—In 1915 the Creighton mine was worked continuously and produced the largest tonnage in its history—the shipments for the year amounting to 778,976 tons.

Below the 10th level of No. 2 shaft a Farrell jaw crusher, 32-inch by 42-inch, is being placed. The arrangement will be similar to that on the 6th level of this shaft, which was described in the 24th Annual Report of the Bureau of Mines.

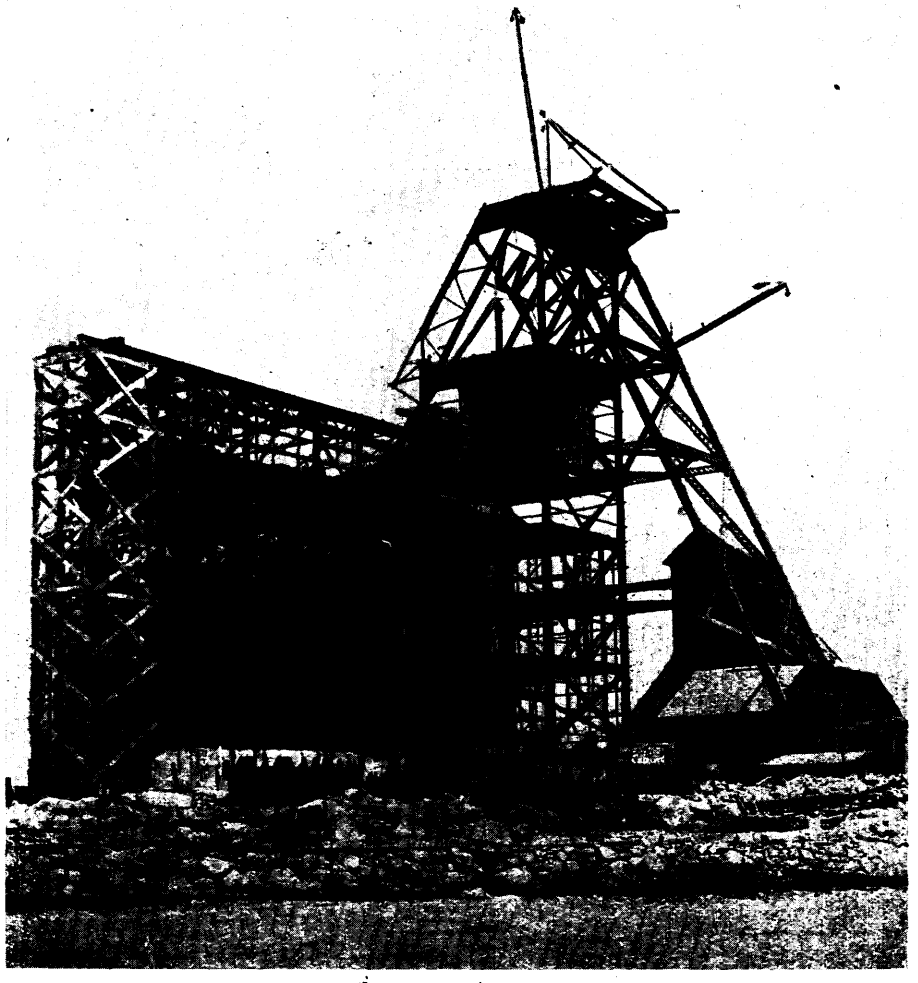
The new five-compartment shaft, known as "No. 3," is being sunk in the footwall 145 feet west of No. 2 shaft. It is being driven at an angle of 55 degrees and on April 14th, 1916, was 1,275 feet deep. It measures 8 feet by 33 feet and contains a manway, two skip compartments and two compartments for handling men and material. The shaft is concreted for a distance of 40 feet below the collar. The skip-track consists of 85-pound rails resting on the wall-plates, which in turn are supported on concrete piers at 7½-foot centres. Four stations have been cut—the 6th, 8th, 10th and 14th. The first three correspond with similarly numbered levels from No. 2 shaft. These main levels are 150 feet apart, measuring along the incline. Intermediate levels are to be driven half-way between these main levels and will be numbered 7, 9, 11 and 13.

On the 6th and 10th levels 4½ and 5-ton storage battery locomotives are now in use. Each locomotive hauls four 56-c.f. side-dumping steel cars, which are automatically dumped at the crushers.

A new magazine has been built by driving an adit into a hill about 1,200 feet west of the main shaft. Near the face of this adit a chamber 27 feet by 50 feet by 9 feet high was excavated. At the face itself a raise with an offset or jog about midway was driven to surface a distance of 45 feet. At this offset a bulkhead extends part way across the raise to catch anything that may fall down. The top of the raise is fitted with two 18-inch elbows and a flanged length of pipe embedded in concrete. The pipe-opening is covered with a screen. The magazine chamber is equipped with bulkheads and floored with two inch by 12 inch lumber resting on 4 inch by 4 inch. All nails are well countersunk and ample provision is made for drainage. The magazine has a capacity of 2,026 boxes of explosive. Near the portal a lateral drift leads to a second chamber, 18 feet by 26 feet by 8

feet high, where a thawing-room is being equipped. The latter will have a capacity of 150 boxes.

A Nordberg double-drum hoist is now in use at the No. 2 Creighton shaft for handling ore. The drums are 7 feet 0 inches diameter and 4 feet 0 inches face, grooved for 1⅛-inch rope. The hoist is equipped with parallel motion post brakes operated by oil thrust cylinders. The hoisting speed is 1,100 feet per minute with



New shaft and rock house under construction, Creighton mine.

a 5-ton load of ore. It is driven by a 350-h.p., 480-r.p.m., 25-cycle motor with limit switches positively geared to each drum. The main gears are of the Wuerst herringbone type. It is proposed to use this hoist for handling the man-cage in the No. 3 Creighton shaft when the permanent installation is made.

A great deal of construction work has been done during the past year and the following new buildings are now completed: Seventy-five dwellings, five boarding-houses, a mechanical shop built of brick and divided as follows—carpenter

shop 40 feet by 40 feet, electrical shop 40 feet by 40 feet, machine shop 70 feet by 40 feet, and blacksmith shop 90 feet by 40 feet. No. 3 shafthouse, brick, 80 feet by 60 feet; main warehouse, brick, 100 feet by 40 feet; storage plant, 80 feet by 40 feet; pipe and steel rack, 60 feet by 40 feet.

The average number of men employed at this mine in 1915 was 1,125. In

Completed shaft and rock house, Creighton mine.

December the employees numbered 1,450, and of these 1,017 were underground workmen. Charles Miller is superintendent.

Dill Quartz Quarry.—The Canadian Copper Company worked the quartz quarry in Dill township during six months of 1915. The average working force during the period was 45 men. H. Whitehead, Quartz., Ont., is superintendent.

No. 2 Mine.—No. 2 mine of the Canadian Copper Company was reopened on February 8th, 1915, and 55,923 tons of ore were shipped during the year. This came from stopes above the 8th, 9th, 10th and 11th levels, and from the 6th level floor which was broken down.

At a point on the 11th level, 300 feet westerly from the bottom of the winze which connects this level with the 8th, a winze has been sunk. The latter has a dip of 45 degrees and is 140 feet deep. Diamond drilling is being done from the bottom of this new winze to locate the lower part of the orebody which is believed to have been displaced by faulting. W. J. Hambly is superintendent. About 100 men are employed.

Vermilion Mine.—The Vermilion mine was worked during all of 1915 by the Canadian Copper Company. Shipments during the year totalled 889 tons. The ore in this deposit is said to contain considerable platinum and palladium as well as nickel and copper.

A two-compartment shaft has been sunk to a depth of 150 feet and levels opened at 75 and 150 feet. Stoping has been carried on above the first level to the northwest and southeast of the shaft. On the second level drifting has been carried on to 53 feet northwest and 92 feet southeast of the shaft. Some cross-cutting has also been done on this level. The orebody has so far proved to be very irregular in form.

The average number of men employed at this property was 25. Charles Collins, of Crean Hill, is superintendent.

Mond Nickel Company

From the five mines of the Mond Nickel Company, in the Sudbury field, 376,602 tons of nickel-copper ore were shipped to the Coniston smelter. A small quantity of siliceous copper ore was also produced from the old Bruce Mines, which are now the property of this company.

Two furnaces were in blast at Coniston until May, 1915, when the third was started, and the three were kept running for the remainder of the year.

The Canadian officials of the company are:—Manager, C. V. Corless; mines superintendent, Oliver Hall, and smelter superintendent, J. F. Robertson.

Bruce Mines.—The Bruce Mines were purchased by the Mond Nickel Company from Messrs. Leonard and Longwell in the summer of 1915. The Taylor shaft (now called "No. 2 Mine"), 65 feet deep, was unwatered in July and drifting was started both northwest and southeast of the shaft at this depth. This shaft is not timbered save for a division between the ladderway and hoisting compartments. The northwest drift was stopped 220 feet from the shaft and the south-east 320 feet. The ore on the west side was stoped out and stoping was begun on the east side. The shaft is to be sunk 100 feet deeper.

At the old No. 4 shaft (now known as "No. 1 Mine"), pumping was started in September. The mine was finally unwatered to the 4th level by the end of November, between thirty and forty million gallons having been handled. This shaft is divided into three compartments and extends to the 4th level, a depth of

327 feet. On the 4th level a drift connects with old No. 2 shaft some 900 feet northerly. Considerable ore is blocked out above this connecting drift. Above the third level, which is at 262 feet, some ore remains on the south side. The north side has been stoped. There were formerly two levels above the third, but this ground also has been stoped.

West of this No. 1 or main vein lies a second parallel vein at a distance of 60 feet. The latter was known as the "Fire lode," or No. 2 vein. It has not been worked since 1878, and but little is known about it. It was connected to the main vein by crosscuts on the first and second levels and apparently has been stoped out to the second level. About 100 feet of drifting was done on this vein on the third level but no ore was encountered.

The necessary mine buildings have been completed near the No. 4 shaft. The machinery includes the following:—

One 300-h.p. Heine tubular boiler.

One 80-h.p. locomotive type boiler.

One 1,000 c.f. cross-compound Rand compressor.

One 600 c.f. straight-line Ingersoll compressor.

One double-drum Jenckes hoist, 12 inches by 18 inches.

One small electric light plant.

Stoping is done with Waugh stopers and drifting with No. 43 Rands. The ore is shipped to Coniston smelter where it is used as converter flux. It consists of chalcopyrite in a white quartz gaugue and contains about 85 per cent. free silica; 1,961 tons of ore were shipped in 1915.

J. H. Stovel was superintendent until March, 1915, when he resigned and was succeeded by A. D. Carmichael. About 75 men are employed.

Garson Mine.—The Garson mine is still the principal producer of the Mond Nickel Company. Ore shipments in 1915 amounted to 193,562 tons. The ore was obtained from the first, second, third, fourth and sixth levels. Most of the floors between the first and second levels were removed and the first level is now worked out except for one small stope.

The orebody between the fourth and sixth levels is being developed. The drifts on the sixth level have been widened to give room for double tracks and preparations made to handle a heavy tonnage, as the orebodies between the fourth and sixth are much larger than on the upper levels. Two-ton cars will be used. These will dump on a grizzly above a raise leading to measuring pockets on the seventh level. A new blacksmith shop, a club house and a combined office and warehouse were completed during the year. About 375 men were employed under Superintendent A. L. Sharpe.

Kirkwood.—The Kirkwood mine of the Mond Nickel Company worked until the latter part of December, 1915, when the machinery was removed. The shaft on the main ore body was sunk to a depth of 210 feet and timbered to 130 feet. The ore produced from this deposit during the year came from a stope west of the shaft on the 210-foot level and east of the shaft on the 130-foot level. East of the shaft on the lower level no ore was found. A small tonnage was obtained from two other ore bodies. One of these, situated some 600 feet west of the main

shaft, was worked to a depth of 110 feet. The second, situated about 500 feet east of the main shaft, was worked to a depth of 50 feet. The ore shipped during 1915 amounted to 38,448 tons. Superintendent J. R. Thoenen had seventy men employed.

Levack Mine.—The developing of the Levack mine was carried on actively in 1915. The five-compartment shaft is now 433 feet deep on the slope. Levels have been opened at 150, 250 and 350 feet vertical depths. Winzes have been sunk from the first to the second level and one raise has been completed from the third to the second level. On the second level drifts have been driven through the centre of the orebody.

On the third level the orebody is larger than on the upper levels, and the following system of development is being followed:—The stopes are planned to be 100 feet long and separated by 40-foot pillars. A drift is run through the centre of the orebody and two crosscuts at right angles to this drift are driven below each stope. The millholes are cut on each side of these crosscuts. The ore from these millholes will be shovelled from wooden platforms into the mine cars. One crosscut also is cut in each pillar. After the outlines of the orebody on the level have been determined by drifting and crosscutting a main haulage drift will be driven in the footwall and connected with all the crosscuts. As the orebody dips at 45 degrees raises will be driven from the main haulage drift to the stope above and these will be used for removing the ore from the upper part of the stope. Raises will also be carried in the centre of every second pillar and will be used as manways and pipeways, connections being made with the stope as required. The ore will be trammed in two-ton cars to a chute leading to a loading pocket below the third level.

A total of 31,755 tons of ore was shipped during the year. This came from two underhand stopes below the first level and from general development work.

The rockhouse was completed and put in operation during the year. It has one feature in which it differs from the other rock houses in the district, viz., the ore from the skips, after passing over a grizzly into a storage bin is fed to the crushers by a pan-conveyor belt. Approximately 30 per cent. of the rock is picked off this belt. After crushing the ore passes through the usual trommels to rubber picking belts, from which the remainder of the rock is picked. The coarse rock is sold to the C.P. Railway for track ballast.

The following buildings of metallic lath and cement plaster construction were completed during 1915:

Office and warehouse	78′ x 33′.
Change house	97′ x 46′.
Machine shop	73′ x 31′.
Round house	72′ x 20′.

The heating plant was equipped by the Taylor-Forbes Company and contains two heating boilers.

Two wooden buildings, a carpenter shop, and a carbide house were completed. In the village one boarding-house, two residences, and fourteen cottages were added.

F. L. Eager, Levack, Ont., is superintendent. About 225 men were employed.

Victoria Mine.—At the Victoria mine of the Mond Nickel Company work continued on both orebodies, and 58,248 tons were shipped.

The shaft was 2,530 feet deep on April 20, 1916, and will be continued to 2,600 feet. The 16th level station was cut at 2,312.

The eastern orebody is now being removed by underhand stoping below the 11th level, and good ore is being obtained. This orebody has not yet been found on the 12th level, but it is now thought that the 12th level crosscut is too far to the south and that further exploration will locate the deposit.

The western orebody is being worked on the 14th and 15th levels. A winze is being sunk below the 15th level to meet a raise from the 16th.

The new Nordberg hoist was put in operation during 1915. It has two drums each 10 feet in diameter and 6 feet 6 inches wide, grooved for 1¼-inch rope. It is driven through herringbone gears by a 470-h.p. motor made by the Siemens Electric Co. of England. The hoist is equipped with the Welch safety device whereby the brakes are automatically applied in case of either overspeeding or overwinding. W. J. Mumford, Mond, Ont., is superintendent.

Worthington.—Shipments from the Worthington mine of the Mond Nickel Company in 1915 totalled 54,589 tons. Of this amount 6,750 tons came from the No. 2 deposit, which was closed down on August 31st, 1915. The main shaft is now (April, 1916) 618 feet deep on the slope. For the first 388 feet it dips at 61 degrees; from this point to 450 feet it is curved to 80 degrees, and below 450 feet it has been sunk at the latter angle. Sinking is still in progress.

On the first level the east drift has been extended to 591 feet east of the shaft and a second ore-shoot opened up. On the second level the east drift is now 525 feet from the station. The third level has been opened at 445 feet vertical depth and drifting done to 245 feet east and 188 feet west of the shaft.

As the ore body on the third level is wider than on the upper levels the method of development has been modified. The main drift runs through the orebody with alternating right and left crosscuts. Raises are put up from the crosscuts and shovelling platforms of the height of the mine cars are built at the bottom of these raises. The stope is then undercut 21 feet above the main level floor instead of on the level as elsewhere in the mine. The crosscuts are placed so as to bring the raises at 30-foot centres. The stope varies from 20 to 50 feet in width. Two-ton cars are used dumping directly into the skips.

The rock-house was burned down on June 25th. A new one, with timber frame and concrete and metallic lath siding, was completed and put in operation on September 15th. The crushing and sorting arrangements are now as follows:—

The skips dump into small bins with grizzly bottoms. These bins feed small dumping tables where the coarse rock is picked out. The ore goes to crusher No. 1 and is fed to two 3-stage bumping tables actuated by belt-driven cams. The ore is picked off and the rock falls upon belt conveyor No. 1 which feeds same to fine rock-crusher No. 3. The coarse rock is fed into crusher No. 2 and passes to a one-stage bumping table, where any ore is picked out and the rock falls upon belt conveyor No. 1 and thence goes to fine rock crusher No. 3. The product from No. 3 crusher is sold to the C.P.R. for track ballast. All crushers are 18 inch by 24 inch Hadfields jaw crushers.

The following construction work was also completed: A brick combined office and warehouse, brick mechanical shop, a pump house containing an eletrically-driven fire-pump, a 30-foot addition to the change house, three new dwellings and a central heating plant. The latter was equipped by the Taylor-Forbes Company and contains two small heating boilers sunk below the ground level. It is a hot-water return-system operating at 5-pound pressure.

R. N. Palmer is superintendent, and 265 men are employed.

Other Nickel Properties

Howland.—The Howland nickel prospect was worked under lease by A. D. Carmichael of Worthington, Ont., during the latter half of 1915. The property is situated in the north half of lot 1, concession II., Drury township, and lies near the Worthington. It is owned by the Canadian Nickel Company of which H. M. Mowat, K.C., Toronto, is president.

Three hundred and seventy-five tons of nickel ore were shipped to the Coniston smelter. This was extracted from an open cut which was carried to a depth of 35 feet. The lessee built a small head frame and provided a boiler and hoist.

Mount Nickel.—The Sudbury Leasing and Development Company, Limited, operated the Mount Nickel mine from March to December, 1915, under lease. The mine is situated in the south half of lot 5, concession 2, Blezard township. It had been idle since 1900.

The shaft, which was straightened by the new company, is now 158 feet deep and is sunk at an angle of 40 degrees. The levels are at 78 and 142 feet. The ore which remained above the first level was stoped out both east and west of the shaft. On the second level stoping had just been started by the lessees when work was discontinued because the Mond Nickel Company did not wish to buy any more ore.

The orebody is from 30 to 40 feet wide. 270,000 tons have been proved by diamond drilling. Shipments for the year totalled 13,000 tons. The ore was teamed to the Stobie branch of the C.P. Ry. and sent to Coniston smelter.

The machinery on the property consisted of a Lambert 125-h.p. boiler, locomotive type, a 5-drill compressor and a 7-inch by 10-inch hoist.

The company is capitalized at $40,000. The officers are:—President, J. A. Holmes; vice-president and manager, Thos. Travers; secretary-treasurer, W. N. Smith, all of Sudbury.

Miscellaneous Mines

Goudreau Mine.—The Madoc Mining Company, a subsidiary of the General Chemical Company of New York, has completed construction work on the Goudreau property and is prepared to ship pyrites beginning with the opening of navigation in 1916.

The deposits on this property have been described in previous reports of the Bureau. "C" deposit, which is 1,500 feet from the rock-house, has been partly diamond drilled and stripped and will be the first deposit to be worked. The open-pit method will be used—the ore being loaded by a Marion steam shovel into

Western side dump cars. The latter will be hauled on a 36-inch guage railroad by a Vulcan Iron Works steam locomotive to the rock-house. The "A" and "Bear" deposits will also eventually be worked. Both have been partly diamond-drilled.

The following buildings were completed in 1915: Boarding-house, office, store, machine shop and magazine, the exterior of all of which is covered with asbestos building lumber and asbestos shingles; warehouse, power house and rock-house, built of steel and reinforced concrete.

The power-house contains the following machinery:—

Two r.t. Keeler boilers, 250 h.p. each, equipped with Sandford-Riley underfeed stokers.

One Ingersoll-Sergeant duplex compressor, 1,200 c.f.

One Cochrane feed-water heater.

Three Worthington pumps for boiler-feed and water tank.

One Hamilton Corliss engine, about 450 h.p. This drives all rock-house machinery by means of a rope drive.

One Ideal engine, 9 inches by 10 inches, driving a 25 k.w. dynamo.

At the rock-house a chute leads to a 30 inch and 48 inch Traylor jaw crusher which crushes to from 4 to 5 inches. A belt conveyor delivers all the crushed material to a No. 6 McCully gyratory crusher set to from 2 to 2½ inches. This product passes to a trommel whence the lump goes to elevator No. 1 and the fines to elevator No. 2. The over-size after being crushed in a No. 3 McCully gyratory passes throught a small storage bin to belt conveyor No. 1. This delivers half of the product to a pair of Superior rolls and half to No. 2 belt conveyor leading to a second pair. The pair of rolls are of the same size, but the second pair will be used only when a large quantity of fines is desired; 100 per cent. fines can be produced if desired. Fines here still comprise ⅜ inch material and under. Both pairs of rolls discharge to elevator No. 2, which delivers to a circular steel storage bin, 20 feet by 20 feet. No. 1 elevator delivers to a similar bin. Both of these bins are placed above the railway tracks and are each equipped with three loading gates.

The company has completed a two-mile railway spur from Goudreau siding to the mine, and has a 30-ton switching engine in use.

The General Chemical Company gave to all employees who, on Dec. 1st, 1915, had been in the employ of the company for a year or more, a sum equal to 10 per cent. of their gross annual earnings; and to each employee who had been in the service for a shorter period a sum equal to 5 per cent. of his gross earnings.

The officers are: President, W. H. Nichols, Jr., 25 Broad St., New York; general manager, Robt. K. Painter, New York; mine superintendent, J. A. Battle, Jr., Goudreau, Ont., via Sault Ste. Marie. At the time of inspection 90 men were employed.

Long Lake Gold Mine.—The Canadian Exploration Company, Limited, worked the Long Lake gold mine, south of Naughton station, continuously in 1915. The mine and plant has been described in former reports of the Bureau.

A 100-foot winze has been sunk at 52 degrees from the second to the third level and considerable exploratory work done on the latter level. R. W. Brigstocke, Naughton, Ont., is manager, and Wm. Rowe, mine foreman.

Massey Mine.—The Massey copper mine, situated north of the village of Massey, on the Soo branch, was reopened in June, 1915, by James F. Flynn. This mine has been idle since 1906, with the exception of a few weeks in 1911, when it was pumped out and sampled. In January, 1916, the Sable River Copper Company, Limited, with a capitalization of $100,000, was organized to work the property. A lease and option to purchase was obtained from the owners, the Massey Station Mining Company. The property involved comprises part of the south halves of Sections 14, 15 and 16, Salter township.

The main, or No. 1, shaft is 530 feet deep with an average dip of 78 degrees to the north. Seven levels have been opened from this shaft. Up to April, 1916, no work had been done at this shaft by the new operators other than pumping and repair work.

A second shaft, known as No. 4, is being sunk 1,600 feet west of the main shaft and was 46 feet deep at the time of inspection.

Several shipments were made during 1915—most of the ore being obtained from an open cut near No. 4 shaft.

Experiments have been conducted on this property with the Callow system of oil flotation and very encouraging results have been obtained. When the alterations in the mill, which was originally built to try out the Elmore oil process, are completed the process will be as follows:—

The ore is first crushed to two-inch ring in a 9 inch by 16 inch jaw crusher and then reduced to ten mesh in a No. 8 Krupp ball mill. An elevator delivers it to a 75-ton bin, from which it is fed by a Challenge feeder to a drag classifier. The overflow goes directly to the Callow flotation machine and the coarse material to a 6 feet by 8 feet tube mill to be reground. The tube mill product then passes to a flotation machine. One Callow roughing or flotation cell is now in use, but it is planned to add three more and also a cleaner cell. The discharge from the roughing and cleaner cells will pass over Wilfley tables as a check on the work done by the flotation process.

The temporary organization of the company is as follows:—President, James F. Flynn, Massey, Ont.; secretary and director, Miss Annie Bell, Toronto; directors, Charles Shiels, R. A. Armstrong, and H. Hanna, all of Massey. The head office is at 76 Adelaide St. West, Toronto. C. G. Daimpre is mine foreman, and Hayden Rood mill foreman. Forty men were employed at the time of inspection.

Moose Mountain.—This iron mine at Sellwood Ont., was not worked in 1915. The experiments in the briquetting plant were continued until December, when all work ceased. Fred. A. Jordan was manager.

A power-house, 48 feet by 65 feet, was built of concrete and metallic lathing. It contains a Westinghouse-Parsons steam turbine with an A.C. turbo-generator rated at 940 k.v.a. maximum, 906 amperes per terminal, 600 volts 3 phase, 60 cycles, 3,600 r.p.m. There is in addition a Robb-Armstrong steam engine, 14 inches by 20 inches, driving a D.C. generator 10 k.w., 125 v., 80 amps., 112 r.p.m.; and a Babcock and Wilcox watertube boiler with a working pressure of 175 pounds. This is equipped with a B. and W. patent steam superheater capable of imparting 150 degrees F. of superheat to the steam when boiler is operated at its normal rating of 400 h.p.

Quarries

Daniels Quarry.—The Oscar Daniels Company, care of Ship Canal, Sault Ste. Marie, Mich., opened a trap quarry in the fall of 1915 on Humbug point, St. Joseph island, Ont. The trap will be used for concrete work at the ship canal.

East Neebish Quarry.—The Dominion Mines and Quarries Company, Limited, are operating a quartzite quarry on East Neebish Island, St. Mary's River. The quartzite, which is said to run 99 per cent. silica, is shipped to the Electro-Metallurgical Company of Niagara, N.Y., to be used in the manufacture of ferro-silicon.

The quarry has a 30-foot face and is at present about 300 feet long. Drilling is done by means of two motor-driven, Clipper churn-drills. The quartzite is loaded by two locomotive cranes into a car which runs to the crushing plant. It is crushed to a maximum size of 3½ inches and then delivered by a system of conveyor belts to a stockpile. Another conveyor belt, running in a tunnel below the stockpile, transfers the quartzite to the wharf and dumps directly into the holds of the boats. An automatic weighing-machine is attached to the last conveyor belt. The present output is about 280 tons daily, but this will be increased to 400 tons daily.

The power plant consists of a 200-h.p. boiler and a 15-inch by 15-inch Skinner steam engine. The latter drives a 125 k.w. generator as well as the crushers and screens. The generator supplies power for the churn drills, conveyors and for lighting.

About 40 men are employed under superintendent I. Appleton. The head office of the company is at Sault Ste. Marie, Mich.; the quarry post office is McLennan, Ont.

Willmott and Co. Quarry.—The Wilmott and Company quartz quarry, near Killarney, on the north shore of Georgian bay, was worked during the season of navigation. A new incline has been built up which the quartz is hoisted in self-dumping cars and delivered to a bin above the crushers. Otherwise, conditions are as mentioned in the 24th Annual Report.

The officers are:—President, Alex. Longwell, Toronto; manager, George W. Rayner, 410 Crown Office Bldg., Toronto; superintendent, Dan Chisholm, Killarney, Ont. At the time of inspection, Aug. 7th, 1915, 20 men were employed.

III.—DISTRICT OF TIMISKAMING

Gold in Beatty, Munro and Maisonville Townships

Cartwright.—The Cartwright Gold Fields, Limited, worked during part of 1915 on the north half of lot 8, concession 5, Beatty township.

The claim was visited on May 11th, 1915, when a shaft had been sunk to a depth of 96 feet. Equipment consisted of two boilers, 40 and 60 h.p., a 280 c.f. compressor, and a 6-inch by 8-inch Jenckes hoist. Twenty-two men were employed at that time.

The company is capitalized at $1,000,000, with head office at 147 Roncesvalles Ave., Toronto. The officers are: President, H. C. Crow, 184 Sunnyside Ave., Toronto; manager, George H. O. Hansen, Matheson, Ont.

Croesus.—The Croesus Gold Mines, Limited, was formed to develop the N.W. ¼, N. ½, lot 10, concession 1, Munro township. This claim was formerly known as the "Dobie-Leyson." The present owners began work in August, 1915, and since that date the mine has produced what are probably the most spectacular specimens of gold-bearing quartz ever discovered in Ontario. While sinking the first 60 feet of the shaft 765 pounds of quartz was removed which contained $47,000 worth of gold.

When the mine was last inspected (March 9, 1916) the shaft, which is inclined at 26 degrees, was 300 feet deep. The drifting done on the several levels was as follows:—

On the 100-foot, 164 feet north and 263 feet south.
On the 150-foot, 175 feet south.
On the 200-foot, 93 feet north and 180 feet south.
On the 250-foot, 110 feet south.
On the 300-foot, 135 feet south.

The following buildings have been completed:—Office, sleeping camp and cook camp; a change-house equipped with steel lockers; a power-house containing: two Goldie and McCullough r.t. boilers, 100 h.p. each; one Sullivan air compressor, type WB2; a 13 k.w. dynamo and an 8-inch by 10-inch steam engine; a machine and carpenter shop containing: a McDougall gap lathe 12-inch by 18-inch by 30-inch, a pipe-threader, a 12-inch rip saw, a 20-inch planer and a 15 h.p. steam engine.

The hoist at present in use is a 6-inch by 8-inch Jenckes, but a 10-inch by 10-inch is on order.

The officers of the company are:—

President, D. M. Steindler, New York.
Secretary-Treasurer, E. L. Steindler, Cobalt.
General Manager, Samuel Cohen, Cobalt.
Manager, Julius Cohen, Matheson, Ont.
Mine Captain, George Thomas, Matheson, Ont.

The head office is at 42 Broadway, New York.

Boston Creek

The gold mines and prospects in the vicinity of Boston Creek are described by A. G. Burrows in another part of this report.

Kirkland Lake Gold Area

Goodfish.—The Goodfish Gold Mines, Limited, owns three claims—L.2194, L.2022 and L.2571—in Morrissette township, near the southwestern corner.

Work was done on these claims from June to November, 1915. This consisted of surface prospecting on all three claims and the sinking of an 80-foot shaft on L.2194. About 80 feet of drifting was done from the bottom of this shaft to the north.

The officers of the company are:—President, Harry Oakes, Kirkland Lake; vice-president, M. J. Brennan; secretary, J. W. Morrison, Kirkland Lake; treasurer, Wm. Costello; director, Edwin W. Kearney, Haileybury.

Kirkland Lake.—The Beaver Consolidated Mines, Limited, has taken an option on the stock of the Kirkland Lake Gold Mines, Limited. The latter company owns 365 acres of land in the township of Teck. Under the terms of the agreement the Beaver company is to expend at least $2,000 a month on development for the next year.

At the present time work is being done on the McKane claim, which adjoins the Teck-Hughes mine. The main shaft has been sunk from 79 to 200 feet and a station is being cut at the 175-foot level.

Floyd Weed, Kirkland Lake, Ont., is superintendent.

La Belle Kirkland.—The La Belle Kirkland Mines, Limited, is capitalized at $2,000,000 and owns the following claims in Teck and Lebel townships, near the south end of Goodfish lake: L 1619, L 1686, L 1687, L 1688, L 1749, L 1750 and L 1751.

Underground work is being confined to Claim L 1751. On April 5th, 1916, when last inspected, the shaft was 265 feet deep. It is at an angle of 60 degrees for 80 feet and 72 degrees for the remainder of the distance. It measures 6 feet by 10 feet outside. The manway is situated above the hoisting compartment, the object of this arrangement being to expose as great a width of the vein as possible during the sinking. On the 100-foot level 70 feet of drifting and 30 feet of crosscutting has been done.

The machinery in use consists of: 2 Robb-Mumford, 60 h.p. boilers; a Canadian Ingersoll-Rand, 480 c.f. compressor and an 8" x 12" Canadian Ingersoll-Rand hoist.

The head office is Sterling Bank Building, Fort Erie, Ont. The officers are: President, Dr. Edward J. Meyer; vice-president, Alfred A. Berrick; treasurer, Frederick A. Meyer; secretary, Chas. S. Cadwallader, all of Buffalo, N.Y.; general manager, Frank C. Loring, Kirkland Lake, Ont.; superintendent, Ernest M. Loring; mine foreman, Andrew Cullen; 30 men are employed.

Lake Shore.—The Lake Shore Mines, Limited, continued the development of one of their claims—L 1557—situated on the south shore of Kirkland Lake.

On April 4th, 1916, the shaft was 312 feet deep and drifting and crosscutting had been done as follows:—On the 100-foot level, 368 feet of drifting; on the 200-foot level, 320 feet of drifting; on the 300-foot level, 340 feet of drifting and 10 feet of crosscutting.

The officers are: President and treasurer, Harry Oakes; secretary and manager, J. W. Morrison; mine foreman, James McMillan, all of Kirkland Lake, Ont. About 20 men are employed.

Lucky Cross.—Interests connected with the Trethewey mine are working the Lucky Cross mine under option. H. S. Robinson of the Trethewey is in charge of the work.

Swastika.—The Swastika mine was purchased at a liquidation sale by F. L. Culver, of Toronto.

Teck-Hughes.—The Nipissing Mining Company, who had an option on the Teck-Hughes mine, stopped work on March 1st, 1915, and later relinquished the option.

On August 1st interests connected with the Buffalo Mines, Limited, obtained control of the stock of the Teck-Hughes Gold Mines, Limited, and construction of a 50-ton cyanide mill was begun. The proposed method of treating the ore is thus described by Mr. A. A. Cole in his report to the T. & N. O. Ry. Commission for 1915, as follows:

"The mill represents a slight deviation from the general practice of slime treatment in Ontario. Certain changes in the general practice were considered advantageous owing to the richness of the ore to be treated and the difficulty with which Kirkland Lake ores are cyanided.

"The primary crushing is to be done in a 16 in. x 10 in. crusher of the Blake type. The ore is then conveyed to a storage bin, from which it is fed to a 5 ft. x 5 ft. ball-mill. The discharge from the ball-mill goes to a Dorr classifier and 5 ft. x 20 ft. tube-mill in closed circuit. The overflow from the classifiers is conducted through the slime plant, completing the treatment.

"Continuous agitation in Dorr tanks is used, and the solution is changed on the pulp when the agitation period is two-thirds over. By this removal of the solution high in gold and by the addition of an active barren solution, an additional recovery of values is anticipated.

"The dissolved values are removed by counter-current decantation in Dorr tray thickeners, followed by a short wash in an Oliver revolving filter. By the use of trays a given washing effect is secured by the use of one-half the number of tanks required for the ordinary thickener installation. The filter is expected to materially reduce the mechanical loss of cyanide as well as to effect an additional recovery of the dissolved gold over what would be obtained by thickeners alone. This feature of the plant is especially advisable, due to the high gold content of the solution and the relatively high strength of cyanide necessary."

A new compressor has been purchased. This is a Canadian Ingersoll-Rand, Class R.P., duplex, power-driven, 20 in. and 12 in. x 16 in.

The mine was pumped out in April, 1916, preparatory to starting underground work.

The officers are:—President, Chas. L. Denison, New York; vice-president, Robt. W. Pomeroy, Buffalo; treasurer, Henry C. Clark, Cobalt; general superintendent, Thos. R. Jones, Cobalt; superintendent, L. W. Ledyard, Kirkland Lake, Ont.; mine foreman, Thos. Whitebread.

Tough-Oakes.—The Tough-Oakes Gold Mines, Limited, worked their mine in Teck and Lebel townships with good results in 1915.

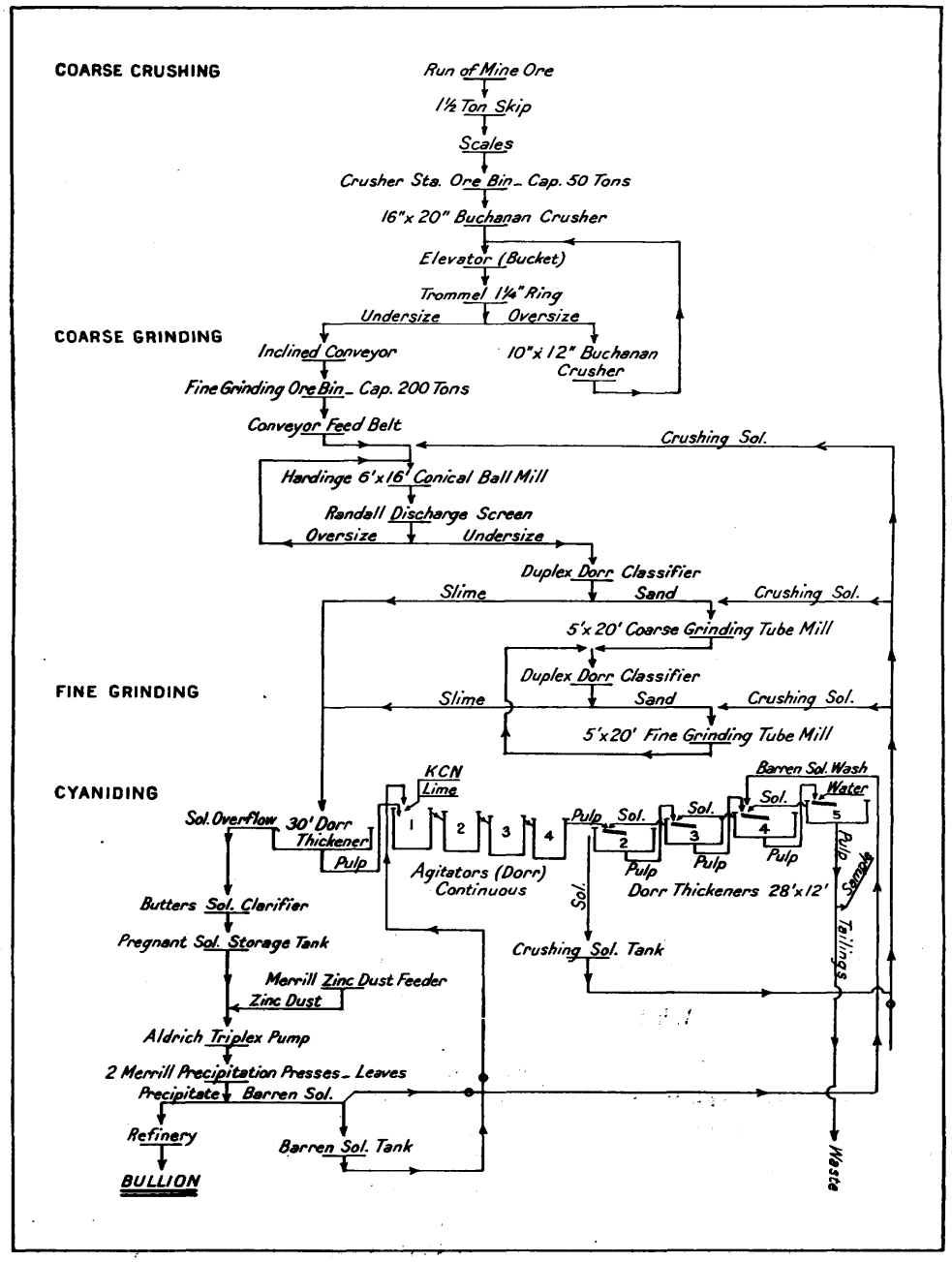
The development work done was:—Shaft sinking, 6 feet; winze sinking, 218 feet; drifting, 1,608 feet; crosscutting, 947 feet; raising, 428 feet; total, 3,207 feet.

A 2½ per cent. dividend, amounting to $66,437.50, was paid.

The new mill began to operate on March 15th, 1915. The total amount treated for the year was 26,196 tons of ore, yielding $551,069.07 worth of gold, and $4,470.07 worth of silver. This was average recovery of $21.21 per ton.

The officers are:—President, C. A. Foster, Haileybury; vice-president, Harry Oakes, Kirkland Lake; secretary, E. W. Kearney, Haileybury; treasurer, J. H.

Tough, Haileybury; C. A. O'Connell, Kirkland Lake, Ont., is manager; John A. Murphy, mine foreman, and Charles A. Randall, mill foreman.



Flow sheet of mill at Tough-Oakes mine. The capacity is 100-125 tons of ore daily.

Smith-Labine.—The Kerr Lake Mining Company of Cobalt began work in December, 1915, under a six-months' option on a group of claims in Maisonville township belonging to Dan Smith and Gilbert Labine. The claims in question are L 3687, L 3688 and L 3689, in concession 2. The camps are about 1¼ miles due north of Sesikinika station.

The claims were visited on March 10th, 1916, when work was in progress on L 3689. A shaft, with an average dip of 35 degrees had been sunk to a depth of 80 feet on a narrow quartz vein carrying free gold and tellurides.

Albert Terrill, Sesekinika, Ont., was in charge of the work and 15 men were employed.

Porcupine Gold Area

Anchorite.—The Coniagas Mines, Limited, has taken an option from the Anchorite Mining Company, Limited, on the three claims known as the Dobie or Armstrong-McGibbon property. The claims in question are M.E. 60, M.E. 61 and M.E. 62, and lie in Deloro township half a mile south of Lot 6, Tisdale township.

The property is an extremely interesting one as a large mass of rusty-weathering carbonate is being tested. The carbonate is cut by many quartz veins. The strike of the vein or band is North 20 degrees East.

The Coniagas company after building camps has started to drive a tunnel into the orebody on claim M.E. 61 and is also doing diamond drilling on the same claim. Two shafts were sunk by the original owners, one 50 feet and one 120 feet in depth; 85 feet of drifting was done from the bottom of the former. C. E. C. Smith, South Porcupine is manager, and John A. MacDonald, superintendent.

Dobie.—The Dobie Mines, Limited, owns 17 claims in different parts of Tisdale township. The Tisdale Gold Mining Company is the holding company.

In 1915 a shaft was sunk by hand-drilling to a depth of 50 feet west of and near the boundary of the Dome Lake Mining and Milling Company property. Considerable trenching was also done. H. G. Carmichael was in charge of the work.

The directors of the holding company are:—President, F. C. Armstrong, New York; vice-president, D. L. McGibbon, Montreal; secretary-treasurer, S. J. LeHuray, Montreal; S. J. Dobie, Haileybury; Wallace Nesbitt, Toronto.

Dome.—The Dome Mines Company, Limited, has an authorized capitalization of 500,000 shares of $10 par value each; 400,000 shares have been issued.

The officers of the company are:—President and treasurer, J. R. DeLamar, New York; 1st vice-president, W. S. Edwards, Chicago; 2nd vice-president and general manager, C. D. Kaeding, South Porcupine, Ont.; 3rd vice-president, H. P. DePencier, New York; secretary, Alex. Fasken, Toronto; directors: J. R. DeLamar, A. H. Curtis and A. V. Stout, New York; W. S. Edwards, Chicago; Alex. Fasken, Toronto; G. C. Miller, Buffalo; J. S. Wilson, Massey, Ont.

For the year ending March 31st, 1916, a total of 347,640 tons of ore was treated in the mill, the average yield per ton being $5.117. The total cost per ton

amounted to $2.559, and was made up as follows:—Mining and hoisting, $0.621; crushing and conveying, $0.104; development charge, $0.60; milling, $0.910; administrative expense, $0.057; general expense, $0.174; taxes and insurance, $0.093. All mining cost on the broken ore reserve left in the stopes (63,000 tons), has been charged directly to current mine operating expense and not to a suspense account.

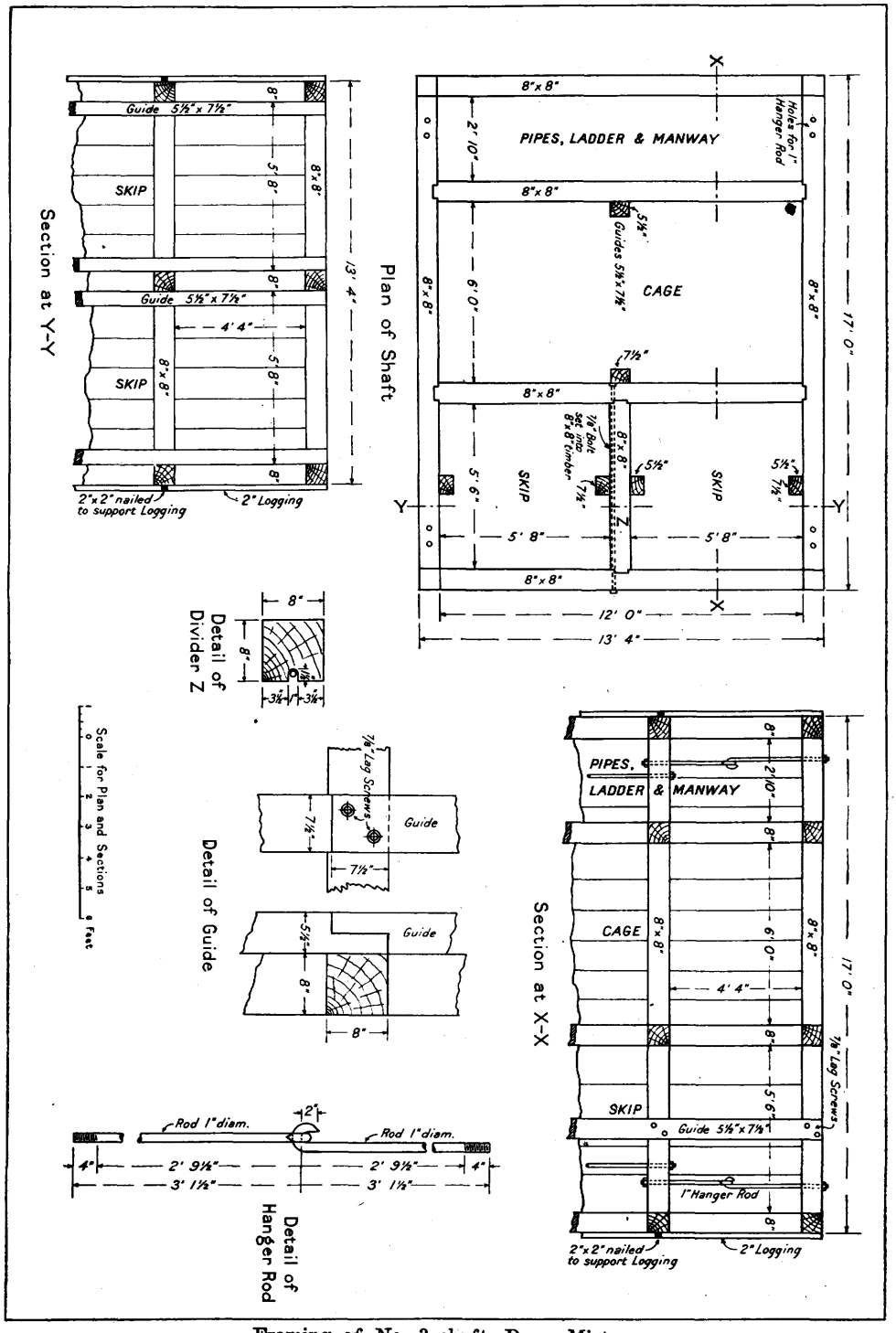
A summary of the development footages for the year follows:—

Level	Drifts	Cross-cuts	Raises	Box-holes	Shafts	Stations	Pockets	Total	Diamond Drilling	Total
1st	.....	679	982	188	.....	.....	.....	1,849	24,866	209,766
3rd	399	229	369	180	.....	25	.....	1,202	109,750	229,950
4th	155	180	.....	.....	.....	.....	.....	335	7,500	41,000
5th	486	871	502	175	.....	40	.....	2,074	.....	207,400
6th	1,166	1,575	566	264	.....	35	37	3,643	343,366	707,666
7th	349	1,006	.....	.....	.....	120	250	1,725	56,400	228,900
Shaft	.....	.....	.....	.....	877	.....	.....	877	.....	87,700
Surface	.....	.....	.....	.....	.....	.....	.....	.....	23,500	23,500
Total	2,555	2,540	2,419	807	877	220	287	11,705	565,382	1,735,882

The additional knowledge gained of the structural geology of the deposit has rendered it possible to segregate from the main mass large zones or bodies of ore which can be separately valued and mined on a selective principle as against the former assumed necessity of non-selective mining. This revision of the ore reserve has eliminated 783,792 tons of unprofitable material and raised the grade of the remaining tonnage. The tonnage developed during the year in new territory was of much higher grade than the average of the ore milled; hence the gross value of the ore reserve has been materially augmented. The reserve as at April 1st, 1916, is estimated at 2,600,000 tons at $6.20=$16,120,000.00.

In order to permit the handling of a large tonnage a new vertical shaft, known as "No. 3," was started in November, 1915. This shaft is the first of its kind in Ontario, being nearly square in cross-section. It measured 13′ 4″ by 17′ outside, and is divided into four compartments. The principal advantage in a shaft of this type lies in having a large cage compartment. Drill steel, timber, track ties and miscellaneous material up to 11 feet in length can be loaded on trucks on the surface and these trucks can be run off on the levels without rehandling the material. The large 5-ton mine cars and storage battery locomotives can be taken to surface for repairs or moved from level to level without dismantling them. On May 1st, 1916, this shaft was 730 feet deep and the timbering, etc., was completed to the 7th level. Stations were cut at the 3rd, 5th, 6th and 7th levels at the following depths respectively: 257, 427, 577 and 727 feet. A loading pocket, 12′ by 14′ by 90′ deep, has been cut below the 6th level. Below this pocket doors will extend across the shaft and deflect the spillage into a small pocket, 3′ 6″ by 5′ 8″, which will be cut at one end of the shaft. This spillage pocket will lead to the next storage pocket below. Sinking will be continued for another 150 feet to the 8th level.

The cage-hoist for the No. 3 shaft is on order from the Nordberg Mfg. Co. It has a single drum, 8′ diameter and 7′ 6″ face, grooved for 1¼″ rope. Two ropes will be attached, one being for a counterbalance. The hoist will be designed to handle these ropes in counterbalance at a depth of 1,500 feet. The estimated



Framing of No. 3 shaft, Dome Mines.

weights are: Cage, 9,500 lbs.; load, 6,000 lbs.; rope, 3,750 lbs. (1,500 feet of 1¼" rope); counterweight, 12,500 lbs. The hoisting speed is 800 feet per minute. It will be driven through herringbone gears by a 150 h.p. motor, 500 r.p.m., 25 cycle, 550 volts. The brake is of the gravity post type. The safety devices consist of—

(1) A solenoid-operated valve which becomes de-energized and applies the brake in case of interruption of the current, whether due to the power falling or to overwinding.

(2) A Welch safety stop which opens the power circuit for any of the following reasons:—

(*a*) In case the hoisting speed exceeds normal at any point.

(*b*) In case operator fails to slow down the hoist at a predetermined and adjustable point and fails to continue to slow down between this point and the landing level.

(*c*) In case of overwind.

(*d*) In case the operator fails to reverse the hoist after the cage has reached the landing or limit of travel.

(*e*) In case power goes off the line for any cause brake will be automatically set.

The skip hoist is also on order from the same company. It is a double-drum hoist driven by a 350 h.p. motor, 500 r.p.m., 25 cycle, 550 volt, through a special herringbone gear. The drums are 7′ diameter with a 4′ smooth face for 1⅛" rope wound in two layers. One drum will be clutched to the shaft and the other keyed. The hoist is to operate normally in balance with the following loads: Ore, 7,000 lbs.; skip, 5,500 lbs.; rope, 3,000 lbs.; a total of 15,500 lbs., including 1,500′ of rope. The hoisting speed is 1,000 feet per minute. The brakes are of the parallel motion post type. The hoist is equipped with a safety device consisting of a solenoid-operated valve, similar to that described above for the cage hoist.

The new shaft is being equipped with a steel head frame, 125 feet high to sheave centres, and ore and waste bins of 850 tons capacity.

The third and lower levels of the mine are being prepared for mechanical haulage. Baldwin-Westinghouse storage battery locomotives with Edison cells are to be used and each is expected to haul a train of six 85-cubic-foot side-dump ore-cars.

Below the fifth level station of the No. 2 shaft a crusher has been placed and is ready to operate. This is a Buchanan jaw crusher with 36" by 54" opening and is driven by two 75 h.p. motors.

In the power plant three 600 k.w. transformers and a second 2,500 c.f. Belliss and Morcom air compressor have been added. The latter is direct-connected to a 450 h.p. motor.

The mill operated 95.0 per cent. of the possible time crushing and treating 347,640 tons of ore with an expenditure equal to $0.910 per ton, a net reduction of $0.089 from the previous year. The treatment results were:—

		Per Ton	Per Cent.
Heads	347,640 tons	$5.50	
Amalgamation Bullion	$1,130,748.95	3.252	59.04
Cyanidation Bullion	648,209.96	1.865	33.84
Total Recovery	$1,778,958.91	$5.117	92.88

The extraction in 1914 was 90.6 per cent. At the close of the fiscal year the mill was treating 34,300 tons per month, compared with 23,630 tons at the beginning of the year. Additions to the equipment are now being made which are expected to increase the capacity up to 45,000 tons per month by about July 1st.

An 8-foot diameter by 30-inch Hardinge conical ball mill, direct connected to a 125 h.p. motor, has been substituted for ten of the stamps leaving 70 stamps still in use. This mill was first run at 26.6 r.p.m. and the capacity was 400 tons per day; it is now being operated at 23 r.p.m. and the capacity has increased to 490 tons. A second mill is being added. Two additional 5′ by 22′ tube mills, direct-connected to 100 h.p. motors, were added for fine grinding. Two 9-foot diameter by 45-foot depth Pachuca tanks, one primary and two secondary Dorr thickeners, 30-foot diameter by 10-foot depth, and two additional 90-frame Merrill slime filter presses, together with the necessary pumps, pipe lines, launders, etc., constitute the slime treatment extension. The sand plant was amplified by raising the sides of the six existing leaching vats 3′ 6″, making them 12 feet deep and adding two more vats, 40-feet diameter by 12 feet deep.

As it was considered possible that the Dome ore body might dip across the eastern boundary into the Dome Extension claim, the Dome Mines Company has secured an 18 months' option on all of the property of the Dome Extension Mines Company.

The Dome now employs approximately 600 men. In addition to the general manager the resident officials now are:—General superintendent, J. C. Houston; mine superintendent, T. P. McNamara; mill superintendent, C. W. Dowsett; mechanical superintendent, W. F. Cowsser; mine captain, A. R. Richards; safety engineer, George Webber.

The above information is taken largely from the fifth annual report of the general manager.

Dome Extension.—In January, 1916, the Dome Extension Mines Company, Limited, reopened their mine near South Porcupine. It had lain idle since 1912. Crosscutting and drifting are now being continued on the second level.

The Dome Mines Company, Limited, which has an eighteen months' option on the property, is also prospecting it by diamond drilling.

The officers are:—President, W. S. Edwards, Toronto; secretary, Alex. Fasken, Toronto; directors, J. S. Wilson, Massey, Ont.; Joseph Tomenson, Toronto; H. C. Anchor, South Porcupine, Ont., is superintendent, and Robert Sloan, mine foreman.

Dome Lake.—In August, 1915, the capital stock of the Dome Lake Mining and Milling Company, Limited, was increased from $1,000,000 to $2,000,000. The total issued capital stock at the end of the year amounted to $1,247,077.

The footages to December 31st, 1915, are as follows:—

	For year 1915.	Total to end of 1915.
Shaft sinking	27	905.6
Winze sinking	40.9	82.9
Raising	157	823
Drifting	796.5	5047.6
Crosscutting	136.0	2297.6
	1157.4	9156.7

The ten-stamp mill treated 11,727.6 tons of ore with an average value of $9.12 per ton. The extraction was 79.93 per cent.—66.1 per cent. being recovered by amalgamation and 13.83 per cent. by concentration. There was 1.89 per cent. of concentrates in the ore crushed. Milling costs amounted to $2.457 per ton.

The directors are:—President, George Taylor; vice-president, A. A. McKelvie; T. McCamus, S. S. Ritchie; all of New Liskeard, Ont.; Chas. L. Sherrill, Buffalo, N.Y.; secretary-treasurer, F. L. Hutchinson, New Liskeard.

Arthur H. Brown, South Porcupine, Ont., is manager, and D. E. Keeley, superintendent.

Hayden.—The Hayden Gold mines, Limited, own five claims, H.R. 937, H.R. 938, H.R. 939, 6899 P and 6900 P in the eastern part of Ogden township about 3½ miles south of the town of Timmins.

The company began work in August, 1915, and built a boiler house, blacksmith shop, carpenter shop, water-tank and a very comfortable set of camps.

A two-compartment shaft has been sunk to 109 feet. On the 100-foot level a crosscut has been driven to 114 feet north of the shaft and at 48 feet north of the shaft 21 feet of drifting has been done to the west and 47 feet to the east; south of the shaft 146 feet of crosscutting has been done.

The officers are:—President and general manager, Wm. H. Hayden, Box 439, Timmins, Ont.; 1st vice-president, H. M. Witbeck, Lockport, N.Y.; 2nd vice-president, W. H. Higgs, Lockport, N.Y.; secretary-treasurer, Willis M. Spaulding, 509 Brisbane Bldg., Buffalo, N.Y. Fifteen men are employed under mine foreman Alex. J. Lawson.

Hollinger Consolidated Mines, Limited.—In May, 1916, a consolidation was arranged whereby the Hollinger Gold Mines, Limited, Acme Gold Mines, Limited; Millerton Gold Mines, Limited, and Canadian Mining and Finance Company, Limited, were merged into one company known as the Hollinger Consolidated Mines, Limited. The capitalization of the new company is $25,000,000.00 in shares of $5.00 par value each. The stock is to be distributed as follows:—

	Shares.	Par value.
In treasury	200,000	$1,000,000.00
Issued to Hollinger shareholders	2,400,000	12,000,000.00
Issued to Acme shareholders	2,100,000	10,500,000.00
Issued to Millerton shareholders	200,000	1,000,000.00
Issued to C. M. & F. Co., Ltd.	100,000	500,000.00
	5,000,000	$25,000,000.00

On the above basis Hollinger shareholders will receive four shares of the new stock for each share of their present holdings.

Canadian Mining and Finance Company, Limited.—Up to the time the Hollinger Consolidated Mines, Limited, was formed, the Canadian Mining and Finance Company, Limited, owned and operated Acme Gold Mines, Limited; Millerton Gold Mines, Limited, and Claim No. 13147, as well as managing the Hollinger Gold Mines, Limited.

The officers are:—President, L. H. Timmins, Montreal; vice-president, J. McMartin, Cornwall, Ont.; treasurer, D. A. Dunlap, Toronto; secretary, John B. Holden, Toronto; general manager, P. A. Robbins, Timmins, Ont.

The "Central" six-compartment shaft, which is situated on Claim No. 13144 near the southwest corner has been sunk to depth of 500 feet. This shaft is concrete-lined. Two compartments have been sunk to a depth of 800 feet and the remaining four compartments will be completed during 1916. Stations have been cut at the 425 and 800-foot levels. The accompanying plan shows the dimensions of this shaft and the arrangement of the concrete lining.

A steel headframe, 120 feet high, has been completed above this shaft, and within it a crushing plant with a capacity of 5,000 tons per 24 hours is to be placed.

A concrete hoist house has also been completed, but the machinery is not yet installed.

Claim No. 13147, which has been included in the consolidation, is the north-east quarter of the south half of lot 10, concession 2, Tisdale township. It lies north of and adjoining the Vipond mine. Near the south-west corner of this claim a shaft has been sunk to a depth of 230 feet and it is intended to continue it to the 400-foot level.

Hollinger Gold Mines, Limited.—The fifth annual report of Hollinger Gold Mines, Limited, shows that this company has developed one of the world's great gold mines. The following information is abstracted from the above-mentioned report, covering the operations of the company for the year 1915:—

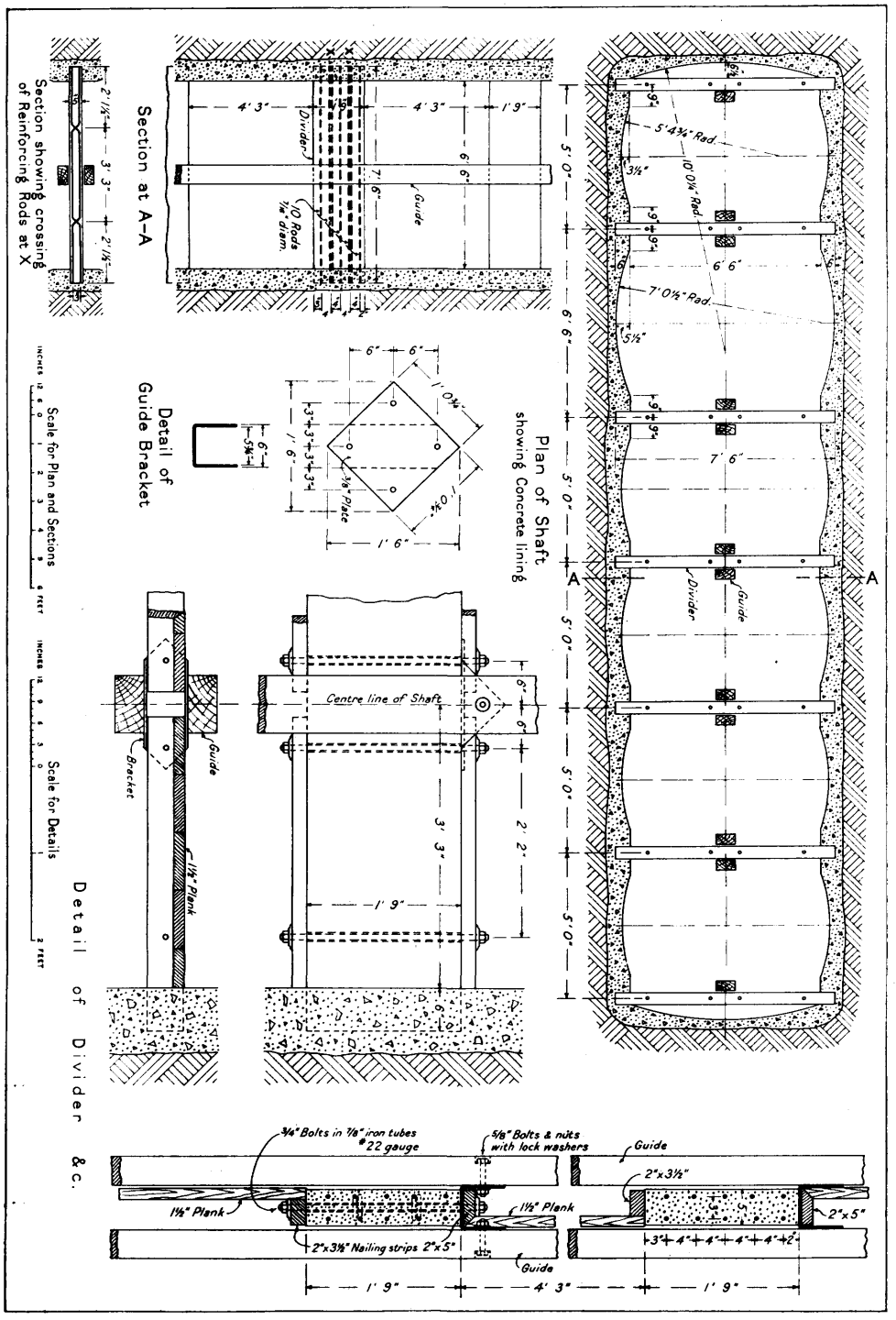
The gold bullion produced in 1915 was valued at $3,169,813.84, an increase of $480,459.04 over the production for 1914. Values per ton were $10.11 in 1915, as compared with $13.67 the previous year. The difference of $3.56 per ton in the value of the ore was compensated for somewhat by a reduction of $1.20 in the working costs per ton. The gross profits amounted to $2,063,466.77.

The progress underground during the year was as follows:—

DEVELOPMENT

Level	Shafts	Drifts	Crosscuts	Raises	Winzes	Diamond Drilling	Timbering Shafts and Winzes	Stopes
	feet	feet	feet	feet	feet	feet	feet	feet
100-foot	.....	262	.....	74	.....	1,054	.....	167
200- "	.....	865	581	87	.....	3,305	.....	1,366
300- "	.....	1,314	85	106	.....	1,029	.....	1,519
425- "	.....	1,542	1,694	302	.....	1,941	24	403
550- "	106	851	477	99	.....	748	115	62
675- "	125	374	.....	135	20	.....	125	.....
800- "	30	589	573	119	125	109	165	.....
950- "	.....	25	7	.....	150	.....	150	.....
1,100- "	.....	.....	59	.....	29	192	12	.....
Total.....	261	5,822	3,476	922	324	8,378	591	3,517

Total development, 10,805 feet.



Framing of central shaft, six compartments and concrete lined, Hollinger Consolidated Mines, Ltd.

STOPING.

Level	Broken ore in stopes, Jan. 1, 1915	Ore broken during 1915	Ore removed during 1915	Broken ore in stopes, Dec. 31, 1915
	Tons	Tons	Tons	Tons
100-foot	18,900	14,039	31,064	1,850
200-foot	36,500	124,813	112,623	48,690
300-foot	11,400	138,662	116,847	33,210
425-foot	.....	39,985	22,265	17,720
550-foot	.....	3,412	2,912	500
675-foot	.....	141	141	.....
800-foot	.....	30	30	.....
	66,800	321,052	285,882	101,970

No. 8 winze now extends from the 300-foot to the 1,100-foot level, and No. 1 vein has been found to persist to the latter depth. The main shaft has been completed to the 800-foot level. Disused stopes are being filled with waste rock. Most of the work of the year has been confined to the upper levels, but a small amount has been done upon the 675 and 800-foot levels.

Trolley-type locomotives are now used for haulage on the 425-foot level.

The ore hoisted from the mine amounted to 334,570 tons, 14.5 per cent. of which came from development.

The net cost of mining is given as $1.898 per ton of ore milled.

The mill treated 441,286 tons of ore, of which 334,750 tons came from the Hollinger and 106,486 tons from the Acme. The costs of treatment were $0.999 for the Hollinger and $1.09 for the Acme ore. The average number of tons of Hollinger ore milled per day was 917. The stamp duty per 24 hours of running time was 14.72. The value per ton in the tailings was $0.40 and the cyanide consumed per ton of ore was 0.574 lbs.

Since April, 1915, 100 stamps have been in operation. Extra tube mills and screening plants are now being provided to relieve the stamps from crushing that portion of the ore which comes from the crushers in a condition fine enough for direct tube milling. The continuous decantation plant is being increased by the addition of two rows of 40-foot tanks. Six Dorr agitators, 26 feet in diameter by 18 feet deep, have been installed to secure a longer period of treatment for the ore. The concentrating plant has been rearranged to make room for the agitators, and a tube mill has been arranged in circuit with two smaller agitators for treating concentrates. It is expected that these alterations will increase the mill capacity to 1,900 tons per day and that a slightly higher extraction will be obtained owing to the increased agitation.

The following is a summary of the reserves:—

—	Tons	Value per ton	Estimated gross value, Dec. 31, 1915	Estimated at Dec. 31, 1914
		$ c.	$	$
No. 1 vein	402,000	12 30	4,946,500	4,958,210
No. 2 vein (north)	144,700	12 75	1,844,500	1,775,740
No. 2 vein (south)	135,700	7 89	1,070,500	885,690
No. 3 vein	21,400	5 28	113,000	169,000
No. 4 vein	223,700	7 84	1,755,100	1,857,670
No. 5 vein	55,100	11 97	659,700	637,760
No. 7 vein	17,000	10 47	178,000	178,000
No. 8 vein	47,300	7 64	361,600	390,740
No. 10 vein	25,400	7 35	186,800	108,000
No. 13 vein	15,600	8 80	137,400	.....
No. 14 vein	131,500	10 25	1,347,700	.....
No. 15 vein	23,500	11 37	267,200	.....
No. 16 vein	27,800	10 67	296,600	[illegible]
No. 37 vein	31,100	9 41	292,700	400,900
No. 38 vein	4,100	10 88	44,600	93,800
No. 41 vein	256,900	8 06	2,069,700	756,780
No. 44 vein	8,000	20 00	160,000	160,000
Miscellaneous	30,000	10 00	300,000	500,000
	1,600,800	10 02	16,031,600	13,358,420

Regarding the future possibilities Mr. Robbins says:—

The entire volume of ore (727,000 tons) so far removed from the mine is the equivalent of approximately the first 160 feet below the surface of those veins which have been developed; or, in other words, the entire tonnage treated to date could have been taken from the first 160 feet below the surface, if each vein had been worked throughout its entire length to that depth. In the present estimate of ore reserves there still remains above the 300-feet level a greater tonnage than has been removed from the mine since operations were first started. In the present estimate of ore reserves there is shown to still remain above the 425-feet level a greater gross value of ore than has been removed since operations were first started. Broadly speaking, our entire productions for the years 1912-13-14-15 of 726,992 tons, containing $9,778,783.77, may be considered to have come from the equivalent of the first 200 feet of depth.

The number of men employed during the year averaged 735.

The officers of the company are:—President, Noah A. Timmins, Montreal; vice-president, John McMartin, Cornwall; secretary-treasurer, David A. Dunlap, Toronto; general managers, Canadian Mining and Finance Co., Limited, P. A. Robbins, Timmins, Ont., general manager.

In addition to the general manager the resident officers are:—Assistant general manager, A. R. Globe; mine superintendent, V. H. Emery; mill superintendent, L. B. Eames; mechanical superintendent, R. W. Robbins; mechanical engineer, Arthur H. Sancton; mine inspector, Benjamin Richards.

Acme.—The Acme Gold Mines, Limited, owns three claims, Nos. 13142, 13143 and 13144, lying to the east of the Hollinger mine.

The company has a capitalization of $3,000,000, divided into 600,000 shares of $5.00 par value each. All the stock has been issued and is held by the Canadian Mining and Finance Company, Limited. The latter company advanced funds for the development work and plant construction, and during 1915 sufficient ore was mined and treated in the Hollinger mill to enable the Acme to pay off its entire indebtedness to C. M. and F. Co.

The report of General Manager Robbins recommending the consolidation of the Acme-Hollinger-Millerton properties gives the following information regarding the Acme Gold Mines, Limited:—

Geological conditions upon claim 13142 are very favorable for the occurrence of gold, and there is a well-mineralized belt extending entirely across the central part of the claim from east to west, from the surface of which very spectacular showings of gold have been obtained in local spots. Surface sampling has shown the existence of a large area of low-grade rock, cut by several high grade stringers within this mineralized zone. Underground development upon this claim has been limited to the sinking of No. 12 shaft to a depth of 179 feet and the driving of 260 feet of crosscuts at that depth. There has also been done 250 feet of drifting.

Claim 13143 possess great possibilities. Conditions are right for the occurrence of gold, and the neighboring McIntyre Company has developed several good ore bodies at points along the north boundary. The limited amount of work which has been done upon this claim has proved up a large amount of ore, but all work has been confined to a narrow strip along the north boundary. The south half of the claim is unexplored except for a few surface trenches.

Claim 13144 is by far the most valuable of the Acme claims at present developed, Within an area of seven acres at the south-west corner there has been exposed by underground and surface workings 1,500,000 tons, estimated to contain over $13,000,000.00. Beyond this there is indicated by the adjacent workings of Hollinger Gold Mines, Ltd., and by surface outcrops, an additional tonnage which will increase the figures given above.

The plant of Acme Gold Mines, Ltd., consists of the following:—

At No. 9 shaft—

Two 100 h.p. double drum electric hoists; one 1,500 c.f. electrically driven compressor; one transformer station of 700 k.w. capacity; one crusher station having a capacity of 700 tons per day; one aerial gear for transporting ore to mill of Hollinger Gold Mines, Ltd.; one hoist house, 43′ by 56′; one timber headframe covered with galvanized iron; one steam boiler for heating; one office and store building, 26′ by 36′; one workshop, 34′ by 54′; one change house with accommodation for 300 men.

At No. 10 shaft—

One hoist house and shop, 18′ by 50′; one head gear; one 10″ by 12″ single-drum hoist.

At No. 11 and No. 12 shafts—

Same as at No. 10 shaft.

The total cost of the plant to date has been $120,507.07.

The development work is described in the above-mentioned report as follows:—

There are four shafts. No. 9 shaft near the centre of claim 13144 has three compartments and is 825 feet in depth, with levels opened at 100, 200, 300, 425, 550, 675 and 800 feet. This is the principal shaft, and is the one at which the largest amount of work has been done. It is the only shaft at present in operation.

Shaft No. 10 is located at about the centre of the north boundary of claim 13143. It is 388 feet in depth, with levels opened up at 140, 240 and 365 feet. This shaft has been shut down for approximately two years, the owners not caring to tie up capital unproductively for an indefinite period, when there was an abundance of other more important work to be carried on.

No. 11 shaft is located near the northeast corner of claim 13144. It has three compartments, is 419 feet in depth, and has levels opened up at 175, 275 and 400 feet.

No. 12 shaft is located near the middle of the east half of claim 13142. It has three compartments, is 179 feet in depth, and has a level opened up at 159 feet.''

Shafts 11 and 12 have been closed down for over a year for the same reason as that affecting No. 10 shaft.

Underground workings consist of:—	Crosscuts.	Drifts.	Raises.
At No. 9 shaft	3,220 feet	8,709 feet	578 feet
At No. 10 shaft	250 feet	675 feet	
At No. 11 shaft	90 feet		
At No. 12 shaft	260 feet	250 feet	
	3,820 feet	9,634 feet	578 feet

Below is given Mr. Robbins' "Summary of Estimated Ore Reserves" of the Acme based on the results of surface sampling and of underground development. An arbitrary allowance of 50 feet has been made for the persistence of ore beyond the exposed faces and bottoms in underground workings. In the case of veins which have had no work done upon them other than the sampling of surface outcrops, an arbitrary allowance of 100 feet in depth for the persistence of these outcrops gives an estimated tonnage of 133,840.

SUMMARY OF ESTIMATED ORE RESERVES.

		Value per ton	Estimated gross value Dec. 31, 1915
	Tons	$ c.	$ c.
No. 5 vein	13,350	7 00	93,580 00
No. 14 vein	33,220	11 48	381,220 00
No. 38 vein	24,500	9 25	226,630 00
No. 50 vein	551,860	8 09	4,465,450 00
No. 51 vein	14,600	6 37	92,900 00
No. 52 and 52A veins	42,770	11 21	479,630 00
No. 53 and 53A veins	333,970	9 54	3,187,430 00
No. 54 and 54A veins	105,020	9 88	1,037,170 00
No. 56 vein	35,460	6 03	213,770 00
No. 58 vein	175,440	8 57	1,502,730 00
No. 59 vein	57,970	9 88	628,690 00
No. 65 vein	49,300	12 47	614,760 00
No. 74 vein	14,000	4 24	59,000 00
No. 79 vein	17,730	5 52	97,800 00
No. 83 vein	24,780	5 80	143,660 00
No. 84 vein	7,230	5 48	39,620 00
No. 85 vein	138,360	8 67	1,199,840 00
No. 88 vein	2,960	14 80	43,800 00
Surface veins	133,840	11 89	1,592,500 00
	1,776,360	9 06	16,100,180 00

Probably the most important surface exposure upon the Acme is vein 55, the outcrops of which may be followed at intervals along the surface for a distance of approximately 1,500 feet. The eastern end of this showing for the last 500 feet of length has an average width of 4.12 feet and carried an average value of $18.76 per ton. No work has been done upon this part of the vein other than the sampling of the surface outcrops.

In the vicinity of shafts 10 and 12 it is probable that future exploration work will develop ore bodies of importance, and it is also probable that careful search will reveal ore bodies upon other, as yet unexplored, portions of the property.

There is also the probability of the various ore bodies persisting to depths considerably below those as yet reached, so the estimate of ore reserves given above cannot be taken as final, but must be considered as an indication of much greater values which we may expect to be disclosed by future developments.

There were treated during 1915 in the Hollinger mill 106,486 tons of Acme ore.

Millerton.—The Millerton Gold Mines, Limited, has a capitalization of $3,000,000.00 divided into 600,000 shares of $5 par value each. The stock, which has all been issued, was owned by the Canadian Mining and Finance Co., Limited, until May, 1916, when the property was transferred to Hollinger Consolidated Mines, Limited.

The Millerton claims are three in number, viz., Nos. 13218, 13219, and 13220. They are situated in lot 11, con. II, Tisdale township, west and southwest of the Hollinger mine.

The underground development is as follows:—

On claim 13218—Shaft No. 6 has been sunk to a depth of 394 feet, with levels at 55, 150, 250 and 379 feet. A total of 876 feet of crosscutting and 435 feet of drifting has been done on the four levels.

On claim 13220—two shafts have been sunk near the south boundary: No. 7 170 feet deep with a level of 167 feet; and No. 8, 45 feet deep.

No work has been done on claim 13219.

Regarding ore reserves Mr. Robbins says in his report of March 30, 1916, recommending the consolidation:—

Owing to the small amount of underground development which has been accomplished, it is not possible to form any dependable estimate of developed ore reserves.

The sampling in underground workings has shown an average value of $7.08 per ton for the ore encountered, and allowing for the persistence of ore for a distance of 50 feet from underground exposures, gives 115,490 tons, with a gross gold content of $818,120.00.

The surface outcrops indicate 1,480 tons, containing $8,880.00 for every foot of depth to which the veins persist.

Throughout the territory explored by underground workings, the country has been subjected to a great crushing action, the rock being fragmental and full of innumerable little quartz veinlets with occasional short, well-defined veins of quartz.

In the crosscut upon the 55-foot level, one section shows an average value of $4.80 over a width of 126 feet, and two portions of this mineralized section show a value of $6.30 over a width of 22 feet.

A consideration of the results so far obtained leads to the conclusion that future development will show a comparatively large tonnage of ore averaging in the neighborhood of $6.50 per ton, and for the purpose of this report we are justified in assuming that 400,000 tons of ore having an average value of $6.50 per ton. It will be understood that these figures are arbitrary assumptions, but they are based upon the data so far collected, together wtih reasonable allowances for the persistence of ore below the surface and beyond underground exposures.

Maidens-McDonald.—The La Rose Mines, Limited, took an option on the Maidens-McDonald claims in Deloro township and commenced work in February, 1916. The claims are H.R. 832 and H.R. 926, and lie three-quarters of a mile south of lot 7, Tisdale township.

There are two prospect shafts on the property. At the time of inspection, May 19th, 1916, both of these were 50 feet deep. It is intended to sink the west shaft, which is on claim H.R. 832, to a depth of 125 feet.

J. C. Nicol, South Porcupine, is doing the work under contract.

McIntyre.—The McIntyre Porcupine Mines, Limited, has a capitalization of $3,000,000.00, divided into shares of $1.00 par value each, all issued. Thirty-one thousand dollars' worth of first mortgage seven per cent. bonds remain outstanding. The company controls the McIntyre Extension Company, which was formed to take over the property and assets of the Pearl Lake Gold Mines, Limited, and also controls and is furnishing working capital to the McIntyre-Jupiter Company, which now owns the Jupiter mine.

The following is extracted from the annual report of the company, covering operations for the year ending March 31st, 1916:—

$779,990.94 in gold bullion was produced during the year, the result of milling 105,758 tons of ore at an average value of $7.71 per ton. Since the beginning of milling operations on the property in 1912 a total of $1,800,241.28 in gold bullion has been recovered from 237,891 tons of ore of an average value of $8.10. The operating profit for the year was $327,524.04.

The development work done is as follows:—

—	Stations	Shafts	Sumps	Drifts	Cross-cuts	Raises	Winzes	Total
Total for year ending March 31, 1916.....	99.40	301.60	26.20	4006.5	1161.7	988.9	.....	6584.5
Total for year prior to April, 1915.....	44.7	1534.3	12.0	10260.6	4821.3	2194.0	221.2	19088.1
Total to date	144.1	1835.9	38.2	14267.1	5983.0	3182.9	221.2	25672.6

5787.3 feet of diamond drilling was also done during the year, making a total of 10,337.4 feet of holes drilled to date.

No. 4 shaft is now being sunk from the 600-foot to the 800-foot level. Sixty-five per cent. of the ore produced from the property to date has been mined in the workings of this shaft.

No. 5 shaft was sunk from the 400-foot to the 700-foot level. Levels were opened at 500, 600 and 700 feet and ore bodies have been found on each. The development work at this shaft during the year has been very satisfactory. The grade of ore mined has increased from $9.20 on the 400-foot level to $12.62 on the 600-foot and $18.72 on the 700-foot.

The McIntyre extension shaft is to be equipped with new hoisting machinery and will be the main hoisting shaft for the works north of Pearl lake. It was sunk from 670 feet to 1,083 feet. A station was cut at 1,000 feet and a pocket station at 1,050. A crosscut is being driven on the 1,000-foot level to connect with the McIntyre No. 5 shaft. On the boundary line between the two claims this crosscut passed through an ore body assaying $15.30 per ton over a width of 25 feet.

Operating costs for the year amounted to $4.2783 per ton. The ore reserves were estimated to be as follows on March 31, 1916:—

	Tons.	Average Value.	Total Value.
No. 4 shaft	17,970	10.15	$182,570.00
No. 5 shaft, No. 5 vein	107,747	12.60	1,359,097.00
No. 5 shaft, contact zone ore bodies.	60,851	9.95	605,054.00
Broken ore in stopes	15,352	6.54	100,407.00
	201,920	11.12	$2,247,128.00

The reserves on March 31, 1915, were estimated at 109,693 tons, with an average value of $7.79, or a total value of $854,436.00. All development work during the year has been on Claim 13307. No attempt has yet been made to develop Claim 13308 or the water lot.

The mill ran 94.4 per cent. of the possible running time, treating 105,758 tons of ore at a cost of 96.8 cents per ton, with a recovery of 95.6 per cent.

Work on the third or "C" unit was begun in September and completed in March. This is a duplicate of units "A" and "B." The capacity of the mill is now 450 tons per day.

New workshops and a transformer house addition, containing three 200 k.v.a. transformers, have been built.

Two hundred and twenty men are employed at the McIntyre and McIntyre-Extension mines.

The directors and officers are: President, A. M. Hay, Toronto; vice-president, Sir H. M. Pellatt, Toronto; J. P. Bickell, Toronto, I. J. R. Muurling, Warrenton, Va.; C. B. Flynn, New York; W. J. Sheppard, Waubaushene, Ont.; J. B. Tudhope, Orillia, Ont.; secretary, M. P. Van Der Voort, Royal Bank Bldg., Toronto.

The operating officers are: Mine manager, R. J. Ennis, Schumacher, Ont.; mine superintendent, J. E. McAllister; mill superintendent, A. Dorfman.

McIntyre-Jupiter.—The McIntyre-Jupiter Company was formed in 1915 to acquire the property of the Jupiter Mines, Limited. The new company is controlled by the McIntyre Porcupine Mines, Limited, and the latter is furnishing working capital for the operations.

Since November, 1915, construction work has been in progress. A new head frame, a sampling house, a power house and a transformer house have been built.

The sampling house arrangements are as follows:—

From a 40-ton bin the ore passes over a Jeffrey travelling grizzly to a 10" by 20" Allis-Chalmers Blake crusher. A 12-inch bucket elevator delivers it to a Snyder sampler which removes 20 per cent. The sample passes through an 8" by 12" Mitchell jaw crusher to a second Snyder sampler which takes out a 10 per cent. sample. The sample goes to a two-ton steel pocket and thence through a set of 10" by 16" Krone rolls. A third sampler then removes 10 per cent. After passing through a pocket to dryers, it is delivered to a Sturtevant sample crusher where it is split. It then goes through a James sample cutter to a Braun grinder. All rejects go to a crushed ore bin.

The power house contains: One Waterous loco. type boiler and one Jenckes r.t. boiler; one Sullivan steam compressor, 14" and 10" by 16", and two Alley and McLennan "Sentinel" compressors of 750 c.f. capacity each, driven by 125 h.p. motors.

A 3,000-foot track leads from the Jupiter shaft to the McIntyre No. 5 shaft, whence the Leschen tramway will carry the ore to the McIntyre mill. R. J. Ennis is manager, and 33 men are employed.

North Thompson.—The North Thompson Associated Gold Mines, Limited, have been actively developing their mine near Timmins, and have been successful in finding several very promising ore-shoots.

A three-compartment shaft has been sunk to a depth of 310 feet and levels opened at 50, 100, 200, and 300 feet. The drifting and crosscutting done to the end of the year was approximately as follows:—

On the 50-foot, less than 50 feet of work.

On the 100-foot, north of shaft a total of about 400 feet and south of shaft have worked to a point 400 feet distant from the shaft.

On the 200-foot, to points 250 feet north and 440 feet south, with considerable intermediate crosscutting.

On the 300-foot, 270 feet of drifting to the north-east and 280 feet of drifting to the south.

The head frame was completed during the year and the plant increased by the addition of a 130 h.p. Robb-Mumford boiler and a 12¼" by 15" double-drum Flory hoist.

The directorate consists of: Chairman of board, F. H. Hamilton, Austin Friars, London, Eng.; directors, E. T. McCarthy, London, Eng.; Edward Hooper, London, Eng.; managing director, Dr. J. M. Bell, Montreal. Canadian office, Dominion Express Bldg., Montreal.

From 40 to 45 men are employed. N. J. Evered, Box 189, Timmins, Ont., is manager.

Porcupine Crown.—The Porcupine Crown Mines, Limited, produced gold in 1915 to value of $613,565.43, after deducting the Mint charges.

The main shaft has been extended to the 500-foot level and the 600 and 700-foot levels are being opened from a winze. A total of 4,569 feet of development and prospecting and 2,616 feet of diamond drilling was done.

The length of ore shoot found to date on the several levels is as follows: 100-foot, 465 feet; 200-foot, 1,062 feet; 300-foot, 1,189 feet; 400-foot, 1,097 feet; 500-foot, 500 feet; 600-foot, 20 feet; 700-foot, 30 feet.

The reserves are given as 150,000 tons with an approximate value of $1,250,000.00.

The mill treated 41,326 tons of ore during the year, having an average value of $14.46 per ton, and 5,093 tons of tailings from the first amalgamation mill, averaging $3.15. The average extraction was 97.70 per cent. for the ore and 85.77 for the tailings. One hundred and twenty men were employed. Costs were as follows:—

		Cost per ton milled.
Mining, development, exploration and underground	$121,242.54	$2.93
Hoisting and tramming	13,482.50	.325
Mill operations	45,036.48	1.09
Power, heat and maintenance	50,935.07	1.23
Mine, general expense	21,394.81	.52
Administration, depreciation, insurance and taxes	25,870.88	.625
Total	$277,962.28	$6.72
Tailings, handling and treatment	4,954.60	.97
	$282,916.88	
Total average cost per ton milled		$6.095

The officers and directors of the company are the same as for the Crown Reserve Mines. M. W. Summerhayes is resident manager and A. S. Crowe, mine foreman.

Porcupine Imperial.—The Porcupine Imperial Mining Company, Limited, worked from June to November, 1915, on claim H.R. 950 in the northern part of Deloro township. This prospect had been idle for some three or four years.

The shaft is, as before resuming work, 112 feet deep. On the 100-foot level about 370 feet of crosscutting and drifting was done in 1915, making a total of approximately 500 feet on the level.

The machinery consists of a 40 h.p. boiler, a 3-drill compressor and a 6″ by 8″ hoist.

Harry L. Taylor, 402 McKinnon Building, Toronto, is president and manager of the company. Nine men were employed under mine foreman Robert Sloan.

Porcupine Miracle.—The Porcupine Miracle Mining Company, Limited, worked their mine in Langmuir township until December 1st, 1915. No. 2 shaft was sunk to a depth of 200 feet. On the 105-foot level 300 feet of drifting was done and on the 200-foot level a station was cut. No. 4 shaft was sunk to 70 feet and a shaft-house built above it.

The manager reports that the crushing capacity has been increased and the cyanide plant completed.

The officers of the company are: President, H. Burton Ransom; vice-president, Wm. S. Mohr; secretary and general manager, George J. Miller, Box 518, South Porcupine, Ont.; treasurer, E. S. Bryant; director, Thomas Wright.

Porcupine Vipond.—Porcupine Vipond Mines, Limited, has an authorized capital of $1,500,000, divided into shares of $1.00 par value each. At the end of 1915, 900,000 shares were outstanding.

The following is extracted from the annual report of the company covering the operations for the calendar year 1915:—

EXPLORATION AND DEVELOPMENT.

The drifts on the 200-foot level were extended to the west limits of the north Vipond lot and the continuation of the ore-bearing zone proven to the boundary of the property.

A vertical two-compartment winze was sunk 220 feet from the 300-foot level and stations were cut at both the 400 and 500-foot points. The winze has been equipped with a cage and exploration work started on both the 400 and 500-foot levels. These levels will be extended to a point under the main working shaft and a connection made with it.

A summary of the work done to date follows:—

	Prior to 1915.	During 1915.	Total to date.
Sinking and raising	795.0	381.5	1176.5
Drifting	2902.4	1198.9	4101.3
Crosscutting	1757.0	218.6	1975.6
	5454.4 ft.	1799.0 ft.	7253.4 ft.
Diamond drilling		524.0 ft.	524.0 ft.

PRODUCTION.

The mill has been in continuous operation during the year. The installation of a 6-foot Hardinge ball mill to replace one of the 4½-foot units and the building of a storage bin for the crusher resulted in increasing the capacity of the mill from 3,000 to 4,000 tons per month.

35,899 tons of ore were treated in the mill, with the following results:—

Gold bullion produced, 11,978.66 fine oz.	$247,598.56
Silver bullion produced, 1,455.39 fine oz.	713.73
Total value recovered	248,312.29
Total value lost in tailings	21,355.13
Gross value of ore treated	269,667.42
Average value per ton treated	7.51
Loss per ton treated (tailings)	.59
Recovery per mile milled	6.92
Extraction per ton milled	92.1 per cent.

The tonnage milled was drawn from the following sources: Stopes, 31,598 tons; development, 4,077 tons; dump, 224 tons; total, 35,899 tons.

ORE RESERVES.

The ore reserves on December 31st were 90,000 tons, valued at $587,280.00, of which 17,130 tons valued at $93,000.00 were broken and stored in the stopes.

The officers and directors are: President, Henry H. Ward; vice-president, H. A. Poillon; vice-president and treasurer, Chas. C. Dickson; secretary, H. F. Karst; all of New York; manager and director, C. H. Poirier, Schumacher, Ont.; directors, R. T. Shillington, Haileybury, and D. I. Jackson.

H. W. Heine is superintendent and F. J. Young, mine foreman. Seventy-five men are employed.

Premier-Langmuir.—The Premier-Langmuir Mines, Limited, own six claims, Nos. P 1307 to P 1312, situated on the Night Hawk river, near and adjoining the southern boundary of Langmuir township.

The geology of the township was described by A. G. Burrows in Vol. XX, Part II, Report of the Ontario Bureau of Mines.

Work was conducted on these claims during part of 1915. Two prospect shafts, 20 and 70 feet in depth, have been sunk and a tunnel has been driven 100 feet on a vein of barite. High silver values are said to have been obtained from parts of the vein.

A tramway, 2,400 feet long, has been built from the mine to the river, and four 40-ton scows have been completed to carry barite to Connaught Station.

The officers of the company are: President, J. A. McIntosh, Toronto; secretary-treasurer, J. B. Aikenhead, London; directors, A. B. Greer, J. W. Cawrse, A. E. Somerville, Geo. McBroom, Fred Rumble, R. H. Cullis, all of London, Ont. Charles W. Dalby, Connaught, Ont., is manager.

Schumacher.—The development work done during 1915 at the mine of the Schumacher Gold Mines, Limited, Schumacher, Ontario, was as follows:—

The three-compartment shaft sunk to 624 feet.

Crosscutting amounting to 1,086 feet on the 300-foot, 400-foot and 600-foot levels.

Drifting amounting to 436 feet on the 300-foot and 400-foot levels.

Raising amounting to 293 feet above the 100-foot and 200-foot levels.

On the 500-foot level a station was cut.

The 150-ton cyanide plant with counter-current decantation was started on September 1st, 1915, and up to the end of the year 9,240 tons had been treated.

The following buildings were also completed during the year: Crusher and conveyor building, assay office, refinery, change house and an addition to the power house to contain a 100 h.p return tubular boiler and a 744 c.f. cross compound compressor. An office building is being constructed.

The costs per ton of ore treated for the month of December are given as follows: Mining cost, $3,533; milling cost, $0.997; total cost, $4.53. These figures do not include any allowance for depreciation.

The officers of the company are: President, F. W. Schumacher, Columbus, O.; vice-president, John B. Holden, Toronto; manager, Joseph C. Houston, Schumacher, Ont.; mine foreman, Maurice Hastie; mill foreman, Robert C. Coffey.

Mr. Houston resigned in February, 1916, and was succeeded by S. A. Wookey as manager.

About 90 men are employed.

Triumph.—Triumph Mines, Limited, bought the property consisting of four claims, in lots 8 and 9, concessions 1 and 2, Tisdale township, formerly known as the "Success Gold Mines." The new company commenced work in December, 1915.

On March 1st, 1916, a shaft inclined at 62 degrees had been sunk 117 feet and about 100 feet of drifting and crosscutting had been done on the 100-foot level.

The equipment consists of a 60 h.p. locomotive type boiler, a two-drill compressor, and a 6" by 8" Jenckes hoist.

The underground work is done by E. S. Henley and H. S. Badger under contract. Eighteen men are employed.

The officers are: President and general manager, Harvey L. Holmes, Box 10, Schumacher, Ont.; secretary and treasurer, N. Nelles, Auburn, N.Y.; directors, J. H. Young, Auburn, N.Y.; Fred W. Thomas, Buffalo; James R. Roaf, Toronto. Head office, Daily Star Building, Toronto.

Dundonald and Clergue Townships

Alexo Nickel Mine.—The Alexo Mining Company, Limited, operated its nickel mine continuously in 1915. The company owns five claims in Concession 3, Clergue and Dundonald townships, near Porquis Junction on the T. & N. O. Ry. All mining to date has been done on the N.E. ¼, S. ½, Lot 1, Concession 3, Clergue township.

Two levels have been opened—the 75-foot and the 125-foot. Part of the ore above the first level has been stoped out to surface, leaving an open pit through which the hoisting is done. A winze connects the first and second levels. The ore body on the first level averages 20 feet in width for a distance of 170 feet and on the second level 37 feet for a distance of 100 feet.

The officers of the company are: President, treasurer and manager, Captain E. F. Pullen, Porquis Jct., Ont.; directors, G. H. Hanning, Toronto; Alex. Kelso, Kelso, Ont.; Frank Pullen, Toronto; Captain C. W. Allen, Toronto; mine foreman, Wm. Dunmead. Captain Pullen left in February to go on active service and was succeeded by Wm. Anderson as manager.

From 20 to 25 are employed. 11,923 tons of ore were shipped in 1915 to the Mond smelter at Coniston.

Timagami Forest Reserve

Golden Rose.—The Golden Rose Mining Company, Limited, worked from March until December, 1915, on a claim situated on the east shore of Emerald Lake, Timagami Forest Reserve. The work done consisted of trenching, opencutting and sinking test-pits. A 6-foot Hardinge Mill and amalgamating plates were used for extracting the gold. About 8 men were employed.

The officers of the company are: President and manager, Edward J. Townsend, North Bay, Ont.; treasurer, James Townsend.

Rand Syndicate.—The above syndicate has been doing some opencutting on claim T.R. 3187 in the township of Strathy about three-quarters of a mile south of Cedar lake in the Timagami Forest Reserve. Shipments of iron pyrites started in the early part of 1916.

A. W. Jackson, 853 Ellicott Square, Buffalo, N.Y., is in charge.

Silver Mines of Cobalt and Vicinity

Adanac.—The Adanac Silver Mines, Limited, commenced work in June, 1915, on the property formerly known as the Pan-Silver in the southeastern part of Coleman township.

There are two shafts—the north or Calumet shaft, 200 feet deep, and the south or Patterson shaft, 226 feet deep. The new company did 375 feet of drifting east of the Calumet shaft on the 200-foot level, making a total of 425 feet of drifting to the east of the shaft. This shaft was then abandoned and a winze started from the 200-foot level of the Patterson shaft at a point 85 feet northeast of the shaft. On the day of last inspection (January 12th, 1916), this winze was 42 feet deep. Fifteen men were employed under superintendent A. W. Grierson, Cobalt, and mine captain Isaac E. Mosure.

The directors of the company are: President, Burr E. Cartwright, Toronto; treasurer, J. P. Bickell, Toronto; secretary, D. A. McArthur, Toronto; J. J. Calvin, Toronto; P. M. Bushnell, New York.

Aladdin.—The Aladdin Cobalt Company, Limited, continued to operate the Chambers-Ferland mine in 1915.

Only No. 4 shaft, which is west of the railway, is now worked. About 1,800 feet of development work was done during the year. A winze, near the west boundary of the claim, has been sunk to a depth of 103 feet below the 350-foot level and levels opened at 76 feet and at the bottom. High-grade ore has been encountered on both levels of the winze.

A new hoist house is being built, and a 10″ by 12″ double-drum Flory hoist will be used in future.

The officers of the company are: President, Major Conrad Jorgenson; secretary-treasurer, F. F. Fuller; directors, Major Chas. Gold, Dennis Herbert, H. B. Sedgwick, all of London, Eng. There is also a Canadian board consisting of R. T. Shillington, C. A. Richardson and Arthur Ferland, all of Haileybury, with Alex. Fasken, of Toronto, secretary. J. A. McVichie, Cobalt, is manager. About 45 men are employed.

Alexandra.—The Alexandra mine on Diabase mountain, Cobalt, was leased by Sydney Smith, of Haileybury, and associates, from the owners, the Canadian Gold and Silver Mining Company. The lessees worked from October, 1915, to March 1st, 1916. The work was done from the 300-foot level and consisted of approximately 300 feet of drifting, 50 feet of crosscutting and 70 feet of raising.

Beaver.—The Beaver mine is situated in the southeastern part of Coleman township and is owned by the Beaver Consolidated Mines, Limited. The officers are: President and general manager, Frank L. Culver, Toronto; vice-president,

C. C. James, Ottawa; secretary-treasurer, H. E. Tremain, Toronto. The board of directors consists of the above-mentioned gentlemen and also F. L. Lovelace, W. T. Mason, W. E. Stevenson, and F. C. Finkenstaedt. J. W. Moffett, Cobalt, is mine superintendent. The head office is 810 Lumsden Building, Toronto, Ont.

Development work done during the fiscal year ending February 29th, 1916, consisted of: Drifting, 3,077.5 feet; crosscutting, 808.5 feet; raising, 848.5 feet; sinking, 476.5 feet; total, 5,211.0 feet. Stoping amounted to 8,480.5 cubic yards.

The main shaft is now 1,400 feet deep and stations have been cut at the 900 and 1,200-foot levels. It is intended to continue sinking until the lower edge of the diabase sill is reached; this contact has been determined by diamond drilling to be approximately 1,670 feet below the surface.

The mill is now treating from 125 to 150 tons a day; 30,093 tons of ore were treated during the year, producing 474 tons of concentrates which yielded 349,900 ozs. of silver. The total recovery of silver for the year was 746,310 ozs.

Two dividends of 3 per cent., or $60,000 each, were paid in 1915.

The company is now carrying out exploratory work on the McKane claim of the Kirkland Lake Gold Mines, Limited. Further mention is made of this work in the description of the mines of the Kirkland Lake area.

Buffalo.—The following information is taken from the tenth annual report of the Buffalo Mines, Limited, covering operations for the year ending April 30th, 1916.

The progress underground was as follows:—

	Raising.	Drifting.	Stoping.
1st Level	80 ft.	128 ft.	30,152 cu. ft.
2nd Level	268	950	112,598
3rd Level	300	480	123,271
4th Level	30	170	25,615
5th Level	30	60	.....
Totals	708	1,788	291,636

Totals to date are,—for shaft sinking, 2,009 feet; for drifting, 18,486 feet; for stoping, 2,657,542 cu. ft.

The mill treated 37,152 tons of milling ore and 1,005 tons of sand and slime tailings, or a total of 38,157 tons treated. Of this amount, 30,079 tons, averaging 19.8 ozs. of silver per ton, were treated by wet concentration and yielded 431,512 ozs. silver, while 8,078 tons, averaging 25.46 ozs. of silver per ton, were treated by combined concentration and oil flotation with a recovery of 197,601 ozs. The cyanide plant treated 6,340 tons of slime averaging 10.54 ozs. of silver per ton and 55,161 ozs. were recovered. The total recovery in mill and cyanide plant was 684,274 ozs.

The total production of silver for the year was 705,055 ozs.

Experiments were conducted with a 50-ton oil flotation plant using the Callow process. The results obtained were so satisfactory that a 600-ton flotation plant is to be built.

The officers and directors are:—President, Charles L. Denison, New York, N.Y.; vice-president, Robt. W. Pomeroy, Buffalo; 2nd vice-president, Harland B. Crandall, New York; secretary and treasurer, George C. Miller, Buffalo; director, Albert W. Johnston, New York. Tom R. Jones, Cobalt, Ont., is general superintendent.

Calumet and Montana.—The Calumet and Montana Consolidated Mining Company, Limited, commenced work in September, 1915, on the property in Coleman township formerly known as the Cyril Lake or Airgiod. This claim has not been worked since December, 1912.

On the date of the last inspection (January 10, 1916), development work done consisted of a two-compartment shaft 225 feet deep and the following drifting and

crosscutting: On the 45-foot level, 50 feet to the east of the shaft; on the 90-foot level, 148 feet to the west; on the 150-foot level, 30 feet to the north, 110 feet to the northeast and 60 feet to the southwest; on the 220-foot level, 120 feet to the north and 55 feet to the south. All the work done in 1915 was on the 90-foot level. The number of men employed was 9.

The officers of the company are: President, H. O. Oswald, Minneapolis, Minn.; secretary, C. A. O'Leary, St. Paul, Minn.; directors, C. V. Patterson, St. Paul, Minn.; W. W. Sloan, Toronto, Ont.; W. G. Weichel, M.P., Waterloo, Ont.; and superintendent, G. G. Thomas, Box 227, Cobalt, Ont.

Casey Cobalt.—The Casey Cobalt Mining Company, Limited, worked their mine in Casey township continuously in 1915.

The ore produced in 1915 came from the 180 and 210-foot levels of No. 3 shaft and from the second and third levels of No. 6 shaft. Diamond drilling has been done from both the 180 and 210-foot levels of No. 3 shaft.

At the time of last inspection, February, 1916, all work on the western claim and in the old workings had ceased and only No. 6 shaft was in use. Ninety-three men were then employed.

The officers are: President, W. R. P. Parker; vice-president, J. P. Watson; secretary, W. W. Perry; all of Toronto. The head office is at 1514 Traders Bank Building, Toronto. John W. Shaw, New Liskeard, is mine manager, and Wm. Hooper, mine foreman.

Casey Mountain.—The Casey Mountain Cobalt Mining and Development Company, Limited, own a mining claim in lot 6, concession II, Casey township.

The property was visited on May 25th, 1915, and at that time the No. 1 shaft was 135 feet deep and 90 feet of drifting had been done on the 50-foot level. No. 2 shaft was 160 feet deep and 30 feet of drifting had been done on the 90-foot level. The manager writes that since that date about 75 feet more sinking has been done. The machinery consists of a 6″ by 8″ Jenckes hoist and a 50 h.p. boiler.

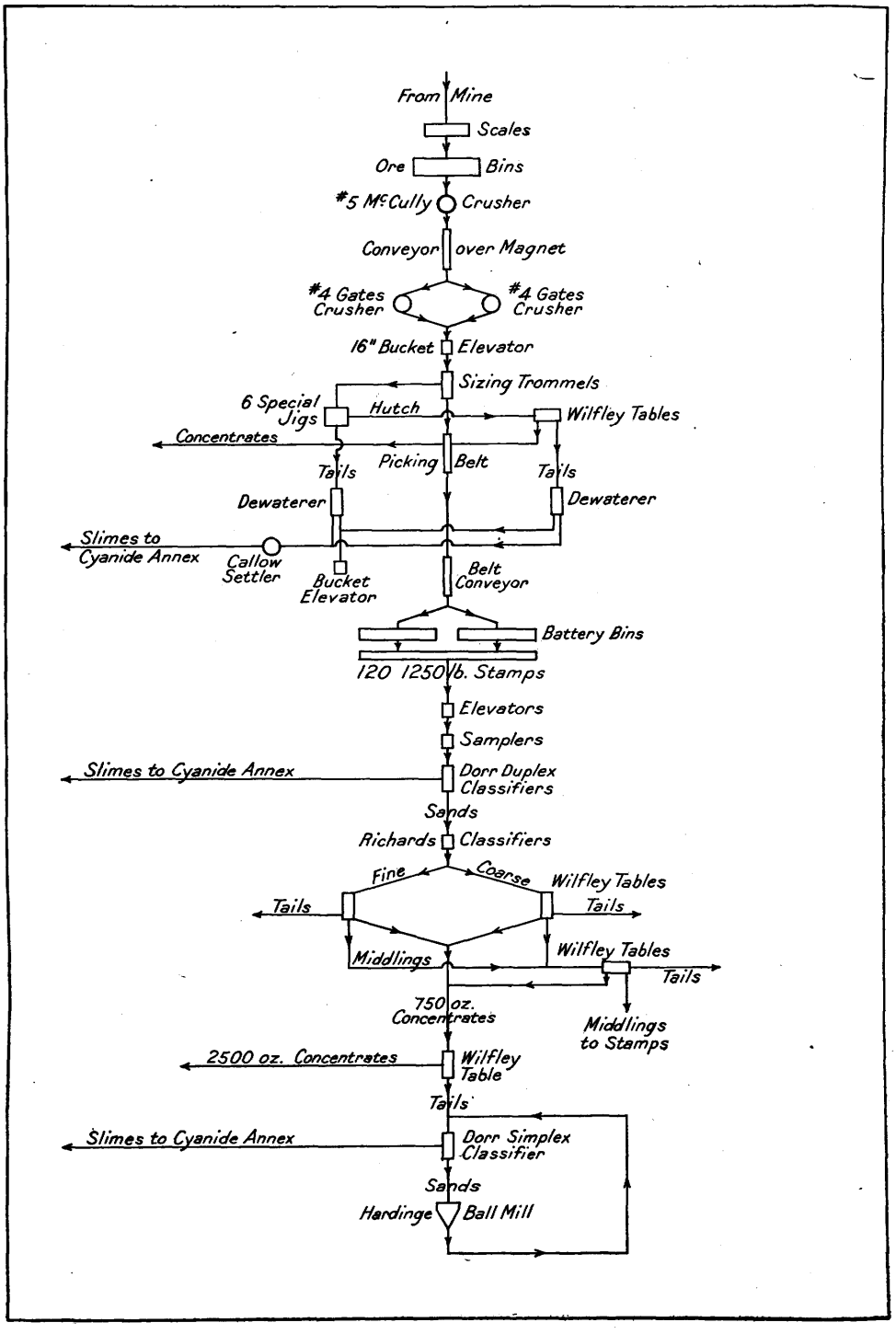
The operating company was the Casey Mountain Syndicate, Regina, Sask.

The officers of the Development Company are: President and manager, R. G. Williamson, Regina, Sask.; vice-president, James Thompson, M.P.P.; secretary, W. A. Staples, 115 Stair Bldg., Toronto, Ont.

Casey Seneca.—The Casey Seneca Silver Mines, Limited, commenced work in July, 1915, on a claim situated in lot 6, concession VI, adjoining the Casey Cobalt mine.

A shaft, 374 feet deep was sunk, and by February 1st, 1916, 244 feet of crosscutting had been done to the east and 256 feet to the west of the shaft on the 345-foot level. John N. MacGuire is doing the work by contract and has 19 men employed.

The officers are: President, S. Harry Worth, Philadelphia, Pa.; consulting engineer and managing director, W. E. Segsworth, Toronto; secretary-treasurer, R. F. Segsworth, Toronto; mine manager, A. C. Bailey, Cobalt. The head office is at 103 Bay Street, Toronto.



Flow sheet, Cobalt Reduction Company, Limited, October, 1915.

Cobalt Comet.—The Cobalt Comet mine, formerly known as the "Drummond," was worked during the first half of 1915 by the Cobalt Comet Mines, Limited, under the management of Mr. E. V. Neelands. The stock of this company is owned by the Caribou Cobalt Mines Company.

In July, 1915, the Kerr Lake Mining Company acquired control of the stock of the Caribou Cobalt Mines Company, and since that date have been carrying on the work principally above the 100-foot level.

Some 30 men are employed. Robert Livermore is manager.

Cobalt Reduction Company.—The mill of the Cobalt Reduction Company, Limited, ran for 96.8 per cent. of the possible time in 1915, six days being lost for lack of power. The stamp duty averaged 2.44 tons per 24 hours. 97,133 tons of ore were milled containing 2,305,900 ounces of silver. The extraction from the milling ore and slime treated was 86.51 per cent. The ratio of ore milled to concentrate produced was 55.83 to 1.

The cyanide plant was started on April 26th, 1915, and ran continuously for the balance of the year. The average daily tonnage cyanided was 135.1.

The chief change made in the practice at this mill is that all the table concentrates are now reconcentrated. The low-grade portion of the re-treated concentrate is passed through the cyanide plant (after sliming in a tube mill) with the slime from the mill tailing.

The company is controlled by the Mining Corporation of Canada, Limited. M. F. Fairlie, Cobalt, is mill superintendent.

Columbus.—Work was resumed in April, 1915, on the property of the Columbus Cobalt Silver Company, Limited, which had lain idle since September, 1914.

No. 2 shaft was sunk to a depth of 415 feet and the third level opened at 400 feet. On this level 300 feet of drifting and crosscutting was done to the north and 70 feet to the east of the shaft. Seven men were employed. Work was discontinued in January, 1916.

The officers of the company are: President, E. L. Woodward, Pittsburg, Pa.; secretary, J. L. Lawson, Toronto; manager, George E. McDonald, Box 64, Giroux Lake, Ont.

Coniagas.—The Coniagas Mines, Limited, with an authorized capital of 800,000 shares of $5.00 par value each, owns and operates the Coniagas mine at Cobalt and also owns the issued capital stock of the Coniagas Reduction Company, Limited.

The following report covers the operations of the mine for the fiscal year ending October 31st, 1915:—

The concentrating mill was operated for 98.83 per cent. of the possible time. Total tonnage milled was 55,437, or an average of 3.02 tons a stamp for 24 hours. Mill heads averaged 23 ounces per ton.

Development work done during the year and the total work done to date are given below:—

	For year ending Oct. 31, 1915.	Total to Oct. 31, 1914.	Total to Oct. 31, 1915.
Shaft sinking, feet	73	802	875
Drifting, feet	626	15,982	16,608
Crosscutting, feet	1,910	6,805	8,715
Winzes, feet	17	519	536
Raises, feet	109	895	1,004
	2,735	25,003	27,738

The total ore reserves are estimated as follows:—

2,136.3	tons high grade ore at 3,000 ounces	6,408,900 ozs.
585	tons high grade ore at 2,000 ounces	1,170,000
117,344	tons mill rock ore at 20 ounces	2,346,880
52,000	tons broken ore at 40 ounces	2,080,000
42,930	tons broken ore at 20 ounces	858,600
1,000	tons mill rock on surface dump at 30 ounces	30,000
	Total	12,894,380

Allowing 20 per cent. for possible over-estimation leaves an ore-reserve on October 31st, 1915, of 10,315,504 ounces.

The average force at the mine for the year was 141 men.

During the year the company earned the title to claims C 1030 and C 1141 on the Gillies Limit and also acquired the Agaunico mine in lot 15, concession 1, Bucke township.

A canvas-table plant was completed and put in operation on October 5, 1915. This is housed in a building 60′ by 70′, and treats 70 tons of 6-ounce slimes per day.

A 6-ton cyanide plant with Butters filter and Dorr agitation is being constructed. This will treat decomposed material which will be diverted at the head of the mill and also the concentrates from the canvas-table plant.

The officers of the company are: President and general manager, R. W. Leonard, C.E., St. Catharines; vice-president, Alex. Longwell, Toronto; assistant to the president and director, R. P. Rogers, Cobalt; secretary-treasurer, J. J. Mackan, St. Catharines; directors, F. J. Bishop, Brantford, and Welland D. Woodruff, St. Catharines.

Major R. P. Rogers, who has been superintendent of the mine for some years, left for overseas service in command of No. 1 Tunnelling Company. Fraser D. Reid is now in charge as superintendent.

Crown Reserve.—The Crown Reserve Mining Company, Limited, capital 2,000,000 shares of $1.00 par value each, operate the Crown Reserve and Silver Leaf claims near Cobalt, and employ about 140 men.

The officers are: President, John W. Carson; 1st vice-president, W. I. Gear; 2nd vice-president, J. G. Ross; secretary and treasurer, James Cooper; assistant secretary-treasurer, John Reid; general manager, S. W. Cohen; resident manager, H. J. Stewart, Giroux Lake, Ont.

Production for the year ending December 31st, 1915, aomunted to 657,395 ounces of silver. This makes the total production of this company to date 19,086,536 ounces. The cost per ounce for the year was 45.01 cents distributed as follows:

Mine operation cost, 25.48 cents; smelting and milling cost, 16.58 cents; other costs, 2.95 cents.

Development work in 1915 amounted to 3,387 feet. This consisted of 214 feet of sinking and raising, 1,976 feet of drifting and 1,197 feet of crosscutting. Total mine development to date amounts to 29,586 feet.

The Drummond Fraction of Cobalt Comet claim was worked until August 1st, 1915, in conjunction with the Kerr Lake Mining Company, Limited.

The Crown Reserve has acquired control of the Globe Consolidated Lease Incorporated Company. The latter will operate a producing gold mine in Trinity county, California.

Dominion Reduction Company Customs Mill.—The Dominion Reduction Company, Limited, operated their 40-stamp mill near Cobalt throughout the year. The ore treated came from the Crown Reserve, Kerr Lake, Cobalt Comet and Drummond Fraction mines. About 60 men were employed at this mill.

The officials of the company are: President, D. M. Steindler, New York; vice-president, M. B. Davis, Montreal; secretary, Eugene L. Steindler, Cobalt; manager, A. G. Kirby, Cobalt; assistant manager, P. L. Blodgett, Cobalt.

Genesee.—The Genesee Mining Company, Limited, was formed in 1915 to prospect the S. W. ¼ of the S. ½ of lot 9, concession I, Bucke township. This claim was acquired under a six-year lease from the United States Cobalt Mining Company.

Work began in the early part of 1916. The property was visited on March 17th, 1916, when the shaft was 60 feet deep with sinking in progress. A drift extends 35 feet to the north of the shaft on the 55-foot level. A 10″ by 12″ Jenckes engine is used for hoisting. Eight men were employed at the time of inspection.

The directors of the company are: President, Ralph H. Gorsline, Rochester, N.Y.; vice-president, — VanZant, Rochester, N.Y.; secretary and treasurer, Alex. Russell, Rochester, N.Y.; A. A. Amos, Toronto, Ontario; manager, Leonard F. Steenman, Cobalt, Ontario.

Glen Lake.—The Glen Lake Mines, Limited, is working the Foster under lease from the Foster Cobalt Mining Company, Limited.

Some drifting and stoping has been done on a vein on the 50-foot level of the 110-foot, or north shaft.

On the 210-foot level of the No. 5, or main, shaft, a crosscut about 1,600 feet long has been driven northwest from the shaft beneath Glen lake. This crosscut started in Keewatin, then passed into diabase and finally into slate. A winze is being started near the face of the crosscut. Fourteen men are employed.

A joint survey of the bed of Glen lake has been made by the Glen Lake, Penn-Canadian and Bailey companies.

The officers are: President, C. B. Flynn, New York; secretary and treasurer, M. P. Van der Voort, 13 Wellington Street East, Toronto; manager and assistant treasurer, Thos. J. Flynn, Haileybury.

Hudson Bay.—The Hudson Bay Mines, Limited, did no work at their No. 1 mine in 1915, but continued exploration at the No. 2 workings situated on the east side of the T. & N. O. Ry. south of the McKinley-Darragh mine. Fourteen men were employed.

During the year ending August 31st, 1915, the work done consisted of: 345 feet of drifting and crosscutting on the second level; 399 feet of drifting and crosscutting on the third level; 16 feet of sinking and 77 feet of raising.

The total footage driven at the No. 2 mine of this company to August 31st, 1915, was as follows:—

	Sinking.	Raising.	Drifting.	Crosscutting.
Shaft No. 1	116	....	....	....
Shaft No. 2	346	....	....	....
1st Level	....	....	849	....
2nd Level	....	....	148	604
3rd Level	....	77	255	144
Totals	462	77	1,252	748

The directors are: President, George Taylor; vice-president, A. A. McKelvie; S. S. Ritchie, T. McCamus, D. M. Ferguson, J. J. Grills, all of New Liskeard; C. L. Sherrill, Buffalo, N.Y.; secretary-treasurer, F. L. Hutchinson, New Liskeard. Arthur H. Brown, South Porcupine, Ont., is manager.

Kerr Lake.—The Kerr Lake Mining Company of New York owns all the stock (600,000 shares of $5.00 par value) of Kerr Lake Mining Company, Limited, of Ontario, 150,000 shares of Wettlaufer Lorrain Silver Mines, Limited, and 200,000 shares of Kerr Lake Majestic Mines. In July, 1915, 837,400 shares of Caribou Cobalt Mines Company were acquired. The latter was the holding company for the Cobalt Comet or Drummond Mine and the acquisition of this stock gives the control of 70 acres adjoining the Kerr Lake claim.

The officers are: President, Adolph Lewisohn; vice-president, Sam A. Lewisohn; secretary and treasurer, E. H. Westlake; mine manager, Robert Livermore, Box 929, Cobalt, Ont.; mine foreman, Wm. Beeton, Giroux Lake, Ont. The New York office is at 61 Broadway.

Development work for the fiscal year ending August 31st, 1915, amounted to 4,226 linear feet. This consisted of: Drifting, 1,996 feet; crosscutting, 2,104 feet; raising, 59 feet, and sinking, 67 feet.

The southeastern part of the Kerr Lake claim is being prospected from No. 3 shaft, which is 340 feet deep. On the sixth or 320-foot level drifts were extended east and west on a strong vein. About 400 feet northwest of the shaft a winze is being sunk from the sixth level on a vein in the Keewatin below the diabase sill. At 50 feet below the collar of the winze 74 feet of drifting has been done. From this same vein on the second level of No. 3 shaft a crosscut was driven through the south central part of the property to the south boundary. The results of the prospecting from this shaft in both diabase and Keewatin have so far not been encouraging.

The largest amount of development work from the main or No. 7 shaft was done on the 140-foot level. As a result of this work the ore reserves in two of the veins are maintained at nearly the figure of the preceding year.

During the year 47,436 tons were hoisted at a mining cost of $4.15 per ton. Of this tonnage 38,286 tons was ore and 9,150 tons waste. The production amounted to 2,036,962 ounces of silver at a total cost of 21.45 cents per ounce. This cost is made up as follows: Mining and development cost, 9.67 cents; shipment and treatment charges, 11.09 cents; administration and general cost, 0.69 cents.

The ore reserves on September 1st, 1915, were estimated to contain 4,172,400 ounces of silver.

La Rose Consolidated.—La Rose Consolidated Mines Company owns the entire capital stock of La Rose Mines, Limited, The Lawson Mines, Limited, Violet Mining Company and 7,262 shares of University Mines, Limited.

The officers and directors are:—President, D. Lorne McGibbon, Montreal; vice-presidents, Shirley Ogilvie and Edwin Hansen, Montreal; secretary and treasurer, Stephen J. LeHuray, Montreal; E. W. Nesbitt, Woodstock, Ont.; W. A. Black and Victor E. Mitchell, Montreal; W. M. Dobell, Quebec; manager, R. B. Watson, Cobalt. The Montreal office is at 201 Inspector St.

The underground work done in 1915 was as follows:—

	Shafts. feet.	Drifts. feet.	Crosscuts. feet.	Raises. feet.	Stopes. c.y.
La Rose	244.5	424	2686.5	106	3991
Lawson	36	230	324.5	143	584
University	...	39	99	61	783
Total	280.5	693	3110	310	5358

La Rose

At the La Rose mine the main work of the year was the exploration of the Extension claim on the west side of the Cobalt lake fault. All the ore heretofore found in the La Rose mine has been on the east side of the fault, where the depth of conglomerate is 150 feet or less. On the west or downthrow side of the fault there is about 400 feet of conglomerate, and to explore this area a new shaft, 407 feet deep, was sunk to the contact, and a level established at 350 feet. On this level 2,225 feet of crosscutting has been done, but to date no ore of value has been encountered.

Lawson

One hundred and fifty-one thousand ounces of silver were produced during the year. Underground prospecting is still being carried on with a small force.

Princess

The company did not operate this mine, but it was worked under lease from May to November, 1915, on a 25 per cent. royalty basis by Sydney Smith and R. T. Walker, of Haileybury. The lessees shipped some ore, the greater part of which came from the party wall between the Princess and Right-of-Way.

University

A total of 1,479 tons of ore, averaging 17.42 ounces, was sent to the concentrator from this mine.

The production of silver for the year amounted to 1,135,142.87 ounces, the net value of which was $526,996.77. The cost of production was 31.64 cents per ounce and the net selling price 50.88 cents per ounce. The net profit on production was $230,662.73.

The only high grade ore at present in sight is a small amount contained in pillars in the La Rose mine.

T. J. Harwood is mine superintendent. Joseph B. Fyfe is mine captain of the La Rose and John Bunclark mine captain of the Lawson.

McKinley-Darragh-Savage.—The McKinley-Darragh-Savage Mines of Cobalt, Limited, during 1915 recovered 838,147 ounces of silver from McKinley-Darragh mine ore and 269,668 ounces from Savage mine ore. This makes the total production of these mines to the end of 1915:—McKinley, 12,682,781 ounces, and Savage, 2,805,786 ounces.

At the McKinley-Darragh mine the underground work done was:—

Levels.	Winze sinking	Raising	Drifting	Cross-cutting	Station cutting	Stoping
	ft.	ft.	ft.	ft.		tons.
50-foot	.....	29.5	114	.....	.....	1,333
60-foot	.....	.....	20.5	.....	.....	192
75-foot	.....	12	342	316	.....	74
110-foot	.....	20	147	.....	.....	20,326
150-foot	.....	129	525.5	348.5	31c.y.	11.406
185-foot	.....	.....	46.5	.....	.....	98
200-foot	.....	4	216	242.5	.....	7,005
235-foot	.....	.....	61	.....	.....	42
250-foot	14.5	40	301.5	35.5	.....	6,919
Totals	14.5	234.5	1,774	942.5	31c.y.	47,395

The total footage driven in the mine to date is 38,471.

At the Savage mine the work done during the year was distributed as follows:

Levels.	Shaft sinking	Winze sinking	Raising	Drifting	Cross-cutting	Station cutting	Stoping
	ft.	ft.	ft.	ft.	ft.		tons
70-foot	.....	.....	.....	48	.....	.....	179
140-foot	.....	26	27.5	81.5	.....	.....	1,176
162-foot	.....	.....	.....	69.5	.....	.....	116
165-foot	.....	.....	.....	39	.....	.....	142
190-foot	.....	.....	156.5	304.5	425	.....	1,524
195-foot	.....	.....	.....	69	44.5	.....	179
240-foot	58.5	37.5	.....	.....	.....	.....	42
290-foot	.....	.....	24.5	142	19	27 c.y.	.....
Totals	58.5	63.5	208.5	733.5	488.5	27 c.y.	3,358

The mill treated 50,912 tons of McKinley ore and 12,749 tons from the Savage. The heads averaged 17,165 ounces and the extraction was 80.9 per cent.

The annual report of the company for 1915 states:

The McKinley property has been so thoroughly prospected that the chance of discovering any ore bodies of great importance is very slight. . . . There remains a con-

siderable amount of exploration to be done at the Savage before the possibilities of the property are entirely exhausted.

The officers and directors of the company are:—President, J. R. L. Starr, Toronto; vice-president, Thos. W. Finucane, Rochester, N.Y.; secretary, J. H. Spence, Toronto; treasurer, Harper Sibley, Rochester, N.Y.; assistant treasurer, Joseph S. Hunn, Rochester, N.Y.; Hiram W. Sibley and G. L. Thompson, of Rochester, N.Y. The head office is in the Canada Life Building, Toronto.

The operating officers are:—Manager, T. R. Finucane; mine captain of the McKinley-Darragh, H. C. McCluskey; mine captain of the Savage, Robert Brocklebank.

Mercer.—The Mercer Silver Mines, Limited, was formed to work the ground lease which reverted to the Peterson Lake Silver Cobalt Mining Company, Limited. The new company began work on August 11th, 1915.

On the 208-foot level of No. 1 shaft, which is on the west side of Cart lake, 40 feet of drifting was done. A shipment made from these workings contained 81,998 ounces of silver.

No. 3 shaft on the east side of Cart lake was sunk from 40 to 212 feet, and on the date of last inspection (March 16th, 1916,) 557 feet of crosscutting had been done to the southwest of the shaft and 290 feet to the north on the 195-foot level.

The footage driven during the fiscal year ending April 30th, 1916, consisted of: Crosscutting and drifting, 1,221.5 feet; sinking, 172 feet; station cutting, 2,688 cubic feet.

The officers are:—President, S. Harry Worth, Philadelphia, Pa.; secretary-treasurer, R. F. Segsworth, Toronto; consulting engineer and managing director, W. E. Segsworth, Toronto; manager, A. C. Bailey, Cobalt.

Thos. D. MacGuire is doing the work under contract and has 16 men employed.

Meteor.—The Meteor Silver Mining Company, Limited, worked their claim on Diabase mountain during all of 1915, closing down in February, 1916.

Drifting and crosscutting were done on the 80 and 115-foot levels.

D. D. Flanagan was in charge and had 12 men employed.

Mining Corporation of Canada.—The Mining Corporation of Canada, Limited, owns 183½ acres in the Cobalt camp comprising the Cobalt Townsite, Cobalt Lake, City of Cobalt, Townsite Extension and Little Nipissing mines. The Cobalt Reduction Company, Limited, is also controlled by the corporation. The company is capitalized at $2,075,000 in shares of $1.00 each, all issued; 1,911,319 shares are held by an English company, Canadian Mining Corporation, Limited.

The ore tonnage statement for 1915 follows:—

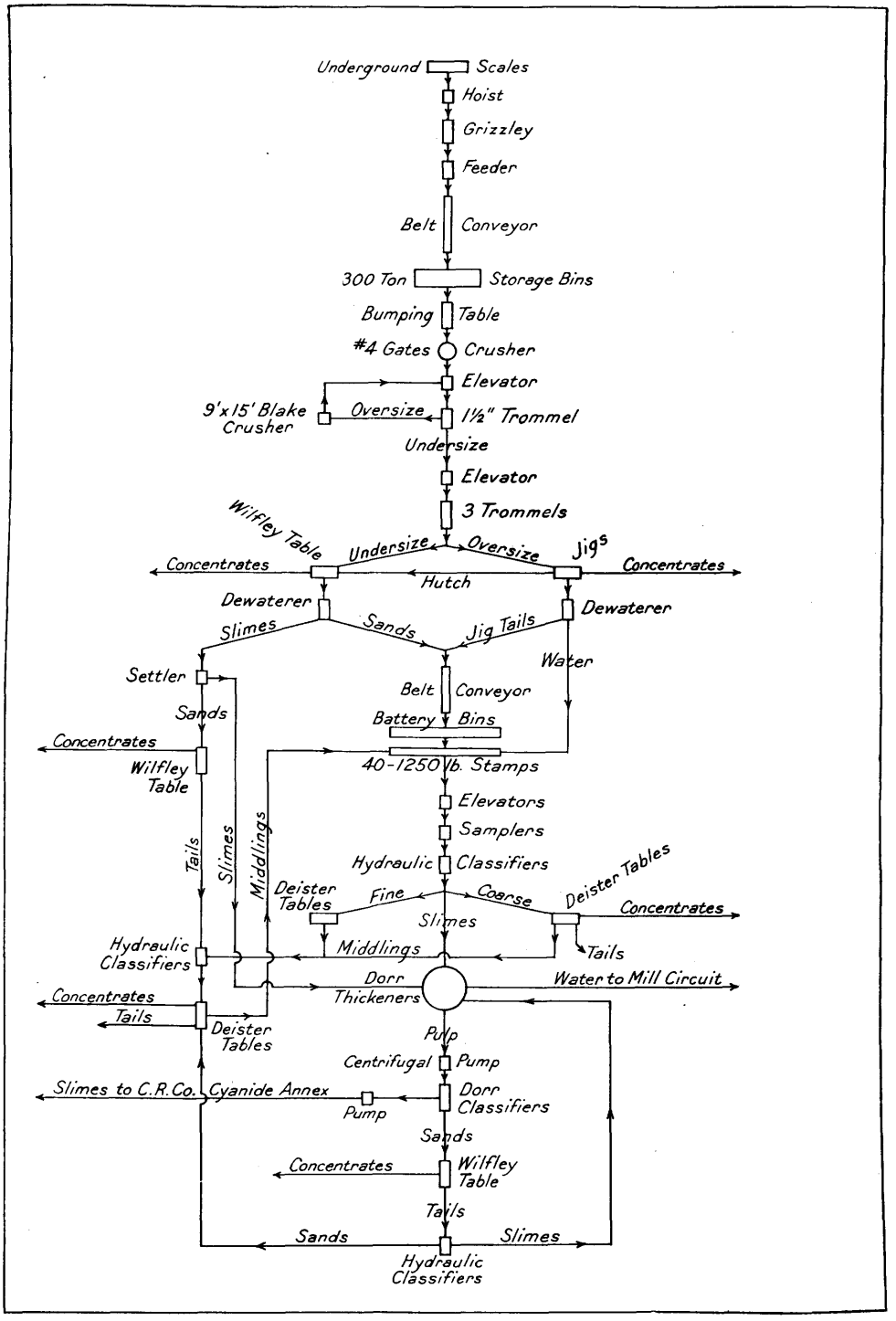
Mine	Hoisted	Broken	Treated
Cobalt Townsite	56,196	51,534	62,528
City of Cobalt	35,252	26,787	35,262
Cobalt Lake	35,678	26,818	35,089
Total	127,126	105,139	132,879

Of the total ore tonnage hoisted, 1,026.31 tons were sent to the smelter; 125,511 tons were treated in the company's mills, and 589 tons were placed on the dump.

The company is now producing more silver than any other company in Canada. The following summary gives an account of the silver produced during the year:—

Shipping Ore	Townsite-City Mine		Cobalt Lake Mine		Total	
	Tons	Ounces	Tons	Ounces	Tons	Ounces
High grade ore	396.6	928,301	369.2	656,685	765.8	1,584,986
Low grade cobalt ore	260.4	56,587	.....	.....	260.4	56,587
Milling ore	97,133.0	2,002,517	34,720.0	919,866	131,853.0	2,922,383
Total	97,790.0	2,987,405	35,089.2	1,576,551	132,879.2	4,563,956

The development and exploration done was as follows:—Drifting and cross-



Flow sheet, Cobalt Lake mill, October, 1915.

other public and private users depended largely on the water of the lake, an alternative supply had to be provided before undertaking the dewatering. A supply was found in the string of lakes south of Cobalt lake, which includes Short lake, Brief lake, North and South Pickerel lakes and Bass lake. The dewatering of Cobalt lake commenced on April 26th, 1915, and was completed on June 5th. To keep the lake dry, the pumps have to operate about half time. The technical details of the project were worked out by O. L. Flanagan.

The Cobalt Lake mill ran 97.3 per cent. of the possible time, deducting 29 days on which the mill was shut down due to shortage of power; 34,719 tons were milled, containing 1,083,280 ounces of silver. The ratio of ore milled to concentrate produced was 37.9. The stamp duty averaged 2.91 tons per 24 hours.

Mention of the Cobalt Reduction mill will be found elsewhere in this report under the heading, "Cobalt Reduction Company."

The average number of men employed by the corporation was 426.4 per working day.

Sir Henry M. Pellatt, Toronto, is president; D'Arcy Weatherbee, Toronto, consulting engineer, and C. E. Watson, Cobalt, resident manager.

National.—The National Mines, Limited, started work on April 1st, 1916, on the King Edward claim, west of Cross lake. The property was last worked by the York Ontario Silver Mines, Limited, who held a lease from the King Edward Silver Mines, Limited. This lease has been acquired by the new company.

Work done in previous years on this claim consists of several shallow shafts and a tunnel driven 1,000 feet in a westerly direction, starting about 30 feet above the level of Cross lake. About 400 feet from the portal a winze was sunk on vein No. 4 to a depth of 352 feet below the tunnel or 500 feet below the surface. In 1913 diamond drilling at this point proved the diabase-Keewatin contact to be at 1,171 feet below the surface. The winze is now to be sunk 500 feet deeper and crosscutting will be done above this contact. The work is to be done by Thomas D. MacGuire, of Cobalt, on contract.

The officers of the company are:—President, H. E. Jackman, Rochester, N.Y.; secretary-treasurer, Ernest C. Whitbeck, 17 Elwood Building, Rochester, N.Y.

Nipissing.—The following information is extracted from the eleventh annual report of the Nipissing Mines Company, covering operations for the year 1915:—

The company produced 4,097,391 ounces of silver, valued at $2,222,256.29. The net receipts were $1,441,427.67. The cost was 19.06 cents per ounce of silver produced, or $10.02 per ton of ore milled.

Twenty per cent. was paid in dividends, or $1,200,000. This makes the total dividends of the company to date 224 per cent., or $13,440,000.

In the high grade mill there was treated 921 tons of Nipissing ore, averaging 2,474 ozs. per ton and 533 tons of custom ore, averaging 2,917 ozs. per ton. The refinery also treated the product from the low grade mill containing over two million ounces. The shipments of cobalt residue amounted to 326 tons. The amalgam is now melted to bullion in one heat in large graphite crucibles mounted in tilting furnaces.

The following is a summary of the work done in the low grade mill:—

	Dry Tons.	Assay Ozs.	Silver Ozs.
Ore treated	77,071	29.62	2,282,614
Bi-products treated	112	1,322.34	148,036
	77,183	31.49	2,430,650
Bullion recovered from above			2,127,372
Extraction			87.52 per cent.

The treatment costs on low grade ore were $3.913 per ton.

Owing to the present high cost of aluminum dust, experiments are now being carried on with the use of sodium sulphide as a precipitant, the resulting silver sulphide being desulphurized by the use of aluminum ingots in a caustic soda solution, before being melted down to bullion.

A small oil flotation plant of four cells is being installed.

The use of Callow screens in the tube mill circuit to collect metallics has been discontinued as the extraction and the cost in the cyanide plant were not improved.

The hydraulic (surface prospecting) plant was operated for six months to remove the soil from an area to the east of Cart lake and to the south of Peterson lake. Some 111 acres were washed at a cost of $372.08 per acre. The amount of overburden removed was 445,563 cubic yards at a cost of 9.27 cents per cubic yard. The average depth of soil was 2.49 feet.

A summary of the underground work done in 1915 follows:—

Shaft No.	Drifting feet	Crosscutting feet	Raising feet	Sinking feet	Total feet	Stoping cubic yards
14 O'Brien	.....	499.0	.....	.....	499.0	.....
63	316.0	521.5	53.0	.....	890.5	2,355
64	171.0	673.0	.....	37.0	881.0	.....
73	1,520.0	3,202.0	744.0	136.5	5,602.5	15,154
80	172.0	757.0	86.5	.....	1,015.5	106
81	.....	.....	.....	6.0	6.0	.....
96	248.0	280.0	85.0	28.0	641.0	551
150	139.5	676.5	105.5	.....	921.5	.....
H. veins 55 & 63	.....	.....	.....	39.0	39.0	365
Totals.....	2,566.5	6,609.0	1,074.0	246.5	10,496.0	18,532

Diamond drilling (all underground at No. 80 shaft), 503 feet.

Claim R. L. 402, lying north of the O'Brien mine, is now being explored from the O'Brien No. 14 shaft. Crosscuts are being run east and west along the boundary between this lot and the O'Brien.

The Little Silver veins were developed through shaft 63 and proved much better than expected. After a steady production throughout the year the reserves in these veins are higher than the estimates of a year ago and amount to 675,000 ozs.

From shaft 64 a crosscut is being driven north on the second level to prospect the conglomerate between vein 64 and the Bucke township line.

The workings from shaft 73 produced the greater part of the ore sent to the mill. Geological study, confirmed by diamond drilling, has shown the conglomerate on the east side of this lot to continue to a depth of 150 feet below the fourth level over a considerable territory.

As the Cobalt lake fault enters Nipissing ground on the dip, and as two of the ore shoots on Cobalt lake ground were found near the boundary, it has been decided to sink shaft 81 to the contact, and from it to thoroughly explore the fault on the Nipissing side of the line.

The reserves of developed and partly developed ore were estimated to be as follows on Dec. 31st, 1915:—

Shaft No.	High Grade Ore		Mill Ore		
	Tons	Ounces	Tons	Assay	Ounces
64	203.1	200,403	4,049	20	80,980
73	1,621.2	2,743,190	73,118	25	1,827,950
80	179.9	385,250	5,570	25	139,250
100	260.4	609,400	11,391	25	284,800
63	195.5	469,900	8,425	24.3	204,770
96	51.9	148,300	2,263	25	56,575
	.....	.....	104,816	24.7	2,594,325
Dumps	.....	.....	75,420	23.5	1,770,950
	2,512.0	4,556,443	180,236	24.2	4,365,275

The following is a summary of estimated ore reserves:—

	Tons.	Assay.	Ounces.
High grade ore	2,512	1,814.	4,556,443
Mill ore	180,236	24.2	4,365,275
Total	182,748	48.8	8,921,718

The officers of the Nipissing Mining Company, Limited, are:—David Fasken, Toronto, president; R. B. Watson, Cobalt, general manager; Hugh Park, Cobalt, manager. The officers and directors of the Nipissing Mines Company, which is a holding company, owning all the stock of the Nipissing Mining Company, are:—President, E. P. Earle, New York; secretary, R. T. Greene, New York; W. H. Brouse, Duncan Coulson and David Fasken, of Toronto; John L. Feeny and August Hecksher, of New York; Denis Murphy, of Ottawa; R. B. Watson, Cobalt.

Northern Customs Concentrators, Limited.—The customs concentrator of the above company at mileage 104, ran continuously in 1915. The ore treated came from La Rose, Seneca-Superior and Right-of-Way mines; 45 men were employed.

The officers of the company are:—President, A. J. Young, 702 Excelsior Life Bldg., Toronto; vice-president, C. J. Booth, Ottawa; secretary-treasurer, A. J. Bourne, Cobalt; directors, M. J. O'Brien, Renfrew, and Dr. C. W. Haentschel, Haileybury; superintendent, A. S. Holmes, Cobalt.

O'Brien.—The development work done at the O'Brien mine in 1915 was as follows:—Drifting and crosscutting, 3,335 feet; raising, 31 feet; sinking, 113 feet; total, 3,479 feet.

The main shaft has been sunk to a depth of 340 feet. The winze (No. 20) from the 300-foot level of No. 6 shaft has been sunk to a depth of 250 feet and four levels have been opened.

A total of 52,883 tons was treated in the mill.

On claim A1 on the Gillies Limit the O'Brien mine has sunk a shaft to a depth of 210 feet and cut stations at 100 and 200 feet. On the 200-foot level 60 feet of drifting had been done to the west and the same amount to the east when last inspected in March, 1916. The work is being done on a vein in the Keewatin series. Considerable graphite is contained in the rock in these drifts.

The mine is owned by M. J. O'Brien. R. H. James resigned as manager in May, 1916, to go on active service and was succeeded by J. G. Dickenson.

Ophir.—The Ophir Cobalt Mines, Limited, began to unwater the north shaft of their mine in southeast Coleman in December, 1915, and then started diamond drilling to determine the depth of the Keewatin-diabase contact. All the work done in past years was in the Keewatin series.

The north shaft is 300 feet deep—the first 140 feet of which is vertical and the remainder dips at about 80 degrees. Drifting has been done on the 100, 200 and 300-foot levels.

The officers of the company are:—President, H. H. Lang, Toronto; secretary, F. L. Cody, 615 C.P.R. Bldg., Toronto; consulting engineer, B. Neilly, Box 542, Cobalt; mine captain, Wm. J. Donaldson, Cobalt.

Penn-Canadian.—The Penn-Canadian Mines, Limited, operated during all of 1915.

For the year ending May 31st, 1916, the development work done was as follows:

—	Drifting	Crosscutting	Raising	Winze Sinking	Totals
3rd level	293.5	137	.....	.....	430.5
Sub-levels	94	27	.....	.....	121
4th level	1,261.5	747.5	53	.....	2,062
Sub-levels	516	.....	48	.....	564
5th level	592	372.5	63	82	1,109.5
Sub-levels	75.5	.....	.....	18	93.5
6th level	143	118	10.5	.....	271.5
Totals	2,975.5	1,402	174.5	100	4,652

There was also 777 feet of diamond drilling done.

By the addition of a Hardinge ball mill the capacity of the mill has been increased to 115 tons per day. To take care of the additional tonnage one roughing table, one double-compartment Hartz jig and two sand tables have been added. The efficiency of the mill has been increased by a system of vortex classifiers and by a table to re-treat the concentrates.

The officers of the company are:—President, Wm. J. Haines, Philadelphia; directors, Spencer D. Wright, Philadelphia; Robt. B. Haines, Jr., Philadelphia; Jansen D. Haines, Des Moines, Ia.; Elliott C. P. Laidlaw, New York. Balmer Neilly, Cobalt, is manager.

Peterson Lake.—The Peterson Lake Silver Cobalt Mining Company, Limited, has an authorized capital of $3,000,000 divided into shares of $1.00 par value each; 2,401,820 shares have been issued.

The work done under Peterson lake for the fiscal year ending April 30th, 1916, consisted of:—Crosscutting, 2,497 feet; drifting, 1,422 feet; raising, 50 feet; winze-sinking, 60 feet; total, 4,479 feet. Most of the work was done from No. 2 shaft. This shaft was connected by a raise with the Little Nipissing, and work was carried on along the northeast shore of the lake. In February, 1916, the workings from Nos. 1, 2 and 3 shafts were abandoned. In October, 1915, the Nova Scotia shaft was unwatered and crosscutting begun on the 200-foot level to intersect some veins outcropping near the shore of Nova Scotia bay.

In February, 1916, an option was taken on the Reliance claim which lies south of the Nova Scotia claim. A limited amount of development work will be done.

Portions of the company's lands were worked under lease by the Seneca Superior Silver Mines, Limited, and the Mercer Silver Mines, Limited.

Dividends paid during the fiscal year amounted to $168,127.40.

The directors are:—President, Sir H. M. Pellatt, Toronto; 1st vice-president, Hugh Blain, Toronto; 2nd vice-president, J. W. Scott; Col. A. M. Hay, Haileybury; Major J. A. Murray. C. H. Manaton, 420 Traders' Bank Bldg., Toronto, is treasurer.

Frank G. Stevens is consulting engineer, and Norman Milne, superintendent.

Right of Way.—The Right of Way Mines, Limited, worked their No. 3 mine near the Silver Queen from March, 1915, to February, 1916. The work was done on the 75 and 120-foot levels. In February, 1916, the No. 2 mine, near the north end of Cobalt lake, was reopened.

The quantity of silver produced in 1915 was as follows:—

Ore shipments containing	102,274.38 ounces.
Ore on hand containing	11,262.76 "
Total	113,537.14 "

The development work done amounted to 522 feet. This consisted of 122 feet of raising, 130 feet of crosscutting and 270 feet of drifting. With the exception of 66 feet of raising all the above work was done at No. 3 mine.

The head office of the company is at 46 Elgin St., Ottawa. The directors are: President, E. Seybold; vice-president, A. W. Fraser, K.C.; secretary-treasurer, E. A. Larmonth; director, C. Jackson Booth, all of Ottawa. D. H. Angus, Cobalt, is mine superintendent.

Rochester.—The Trethewey Silver Cobalt Mining Company, Limited, commenced work in July, 1915, on the Rochester claim in southeast Coleman. A crosscut is being driven in a southwesterly direction from the 300-foot level of the Lumsden Mining Company's main shaft to prospect the Keewatin formation beneath Brady lake. Eight men are employed. H. S. Robinson is superintendent and Chas. A. Froats, mine captain.

Seneca-Superior.—The Seneca-Superior Silver Mines, Limited, has a capital of 500,000 shares of $1.00 par value each. 478,884 shares have been issued.

Exploration was continued on the second and third levels, but no new ore bodies were found. A winze, 79 feet deep, was sunk from the floor of the fourth or 335-foot level at a point 430 feet southeast of the east shaft. Fifteen feet below the collar this winze entered the Keewatin formation. The ore continued into the Keewatin about 45 feet. The mine will probably be worked out in the spring of 1916.

The following is a summary of underground development to the end of 1915:

—	1912	1913	1914	1915	Total.
Drifting on vein—feet	346	645	780	85	1,856
Drifting—exploratory—feet.	737	3,453	2,514	960	7,664
Sinking and raising—feet...	121	351	152	106	730
	1,204	4,449	3,446	1,151	10,250

During the year 25,194 tons of ore and 4,375 tons of waste were hoisted. This tonnage of ore was put through the mill and produced:—

Shipping ore		481.0 tons
Fines for concentrating—8,654 tons which produced—		
Jig concentrates	145.6 tons	
Table concentrates	387.6 "	
		533.2 tons
		1014.2 tons

Ratio of ore milled to concentrates, 16 to 1.

Production for the year was 2,047,150 ounces of silver, making a total production of 5,001,870 ounces since 1912.

The officers of the company are:—President, S. Harry Worth, Philadelphia, Pa.; vice-president, F. W. Zoller; treasurer, R. F. Segsworth, Toronto; managing director, W. E. Segsworth, 103 Bay Street, Toronto; manager, R. H. Lyman, Cobalt.

Shamrock.—The Shamrock Consolidated Mines, Limited, renewed operations in August, 1915, on their claim north of and adjoining the Beaver mine.

The shaft is 417 feet deep with levels at 100, 200, 300 and 400 feet. All of the work done since reopening has been on the 400-foot level. 197 feet of crosscutting was done here in 1915 in the diabase at about 40 feet below the Keewatin-diabase contact. Nine men were employed.

The officers are: President, Peter Kirkegaard, Toronto, Ont.; secretary, Joseph Montgomery, Confederation Life Bldg., Toronto; superintendent, A. M. Bilsky, Cobalt; mine foreman, Walter Purdy.

Silver Queen Mine.—The Silver Queen mine was worked under lease from June 22nd, 1915, to Jan. 22, 1916, by E. V. Neelands and D. H. Angus, of Cobalt.

The mine is the property of the Cobalt Silver Queen, Limited. Dr. E. P. Smith, 1323 Traders' Bank Bldg., Toronto, is president.

Temiskaming.—The main shaft of the Temiskaming Mining Company, Limited, is being sunk to the lower diabase-Keewatin contact. At the date of last inspection (March 14, 1916) it was 1,050 feet deep with sinking in progress. A station has been cut at the 835-foot level.

The work done in the mine in 1915 consisted of:—Drifting, 2,717.5 feet; crosscutting, 1,301.0 feet; shaft sinking, 43.5 feet; winze sinking, 84.0 feet; raising, 617.5 feet; making a total of 4,763.5 feet.

Stoping was carried on to the extent of 8,835.1 cubic yards.

The mill treated 26,927 tons of ore and produced 390.85 tons of concentrates from which 509,073.62 ounces of silver were recovered.

The production for the year was 1,456,894 ounces of silver. This makes the total production of the mine to date 9,116,404 ounces. The high grade ore averaged 6,413 ounces per ton and the mill concentrates averaged 1,302 ounces per ton.

The officers are:—President and general manager, F. L. Culver; vice-president, W. T. Mason; treasurer, H. E. Tremain; secretary, R. Graham. The head office is in the Lumsden Building, Toronto.

The resident officers are:—Superintendent, J. W. Moffett, Cobalt, Ont.; mine foreman, W. D. Cooper; mill foreman, C. E. Reese.

Trethewey.—The mine of the Trethewey Silver-Cobalt Mine, Limited, was worked only from January 1st to February 28th in 1915. During this period 295 feet of development work was done, making the total development to date 24,130 feet. In the mill 6,113 tons of ore were treated at a cost of $1.18 per ton and yielded 85,004 ounces of silver.

The positive ore reserves at December 31st, 1915, are estimated at 26,774 tons, with a total silver content of 507,339 ounces.

The company has purchased control of the Rochester mine in southeast Coleman. The work done at this property is described elsewhere in this report.

Claim A.98 on the Gillies Limit was also acquired during the year. This claim is on the diabase-Keewatin contact south of Giroux lake.

On two claims adjoining the Huronia mine, in Gauthier township, 1,725 feet of diamond drilling was done. As no orebody of economic importance was cut, the option was allowed to lapse.

The officers of the company (with head office at 1428 Traders' Bank Building, Toronto) are as follows:—President, Alex. M. Hay, Haileybury, Ontario; vice-president, S. R. Wickett, Toronto; secretary-treasurer, L. J. Pashler, and directors: Alex. M. Hay; T. E. Leather, Hamilton; W. J. Sheppard, Waubashene; Gordon Taylor, Toronto; James B. Tudhope, Orillia; S. R. Wickett, Toronto.

Stuart M. Thorne retired from the management to go on active military service. He was succeeded by H. S. Robinson as manager.

Twentieth Century.—The Twentieth Century Mining Company, Limited, did some work on the property in lot 1, concession 6, Coleman township, formerly known as the "Century." The shaft was pumped out in July and work was carried on intermittently until January, 1916. It is reported that 200 feet of drifting was done on the 350-foot level east of the shaft.

Sidmore Seager, Buffalo, N.Y., is president, and L. R. Lipton, Buffalo, manager.

Elk Lake

Mapes-Johnston.—The Mapes-Johnston Mining Company, Limited, own claim R.S.C. 79, situated north of Silver lake, in the township of Mickle. Work was suspended from March to November, 1915.

Since last Annual Report was written a little stoping has been done on the 100-foot level east of the shaft, and a winze has been sunk to a depth of 80 feet below the 190-foot level. At a depth of 65 feet in the winze a level has been opened and 40 feet of drifting done to the northeast and 38 feet to the southwest. The winze is now being sunk deeper. Twenty-two men are employed.

The officers of the company are:—President, John J. Cohoe, Brantford; managing director, E. L. Gould, Brantford, Ont.; superintendent, D. G. Oliver. Elk Lake, Ont. The head office is at Brantford, Ont.

Paragon.—The Paragon Silver Mining Company, Limited, worked their property in Willett township until December 1st, 1915. The shaft has been sunk to a depth of 168 feet. The drifting done consisted of 40 feet on the 90-foot level and 32 feet on the 160-foot.

The officers of the company are:—President, Donald McKay, M.D.; first vice-president, Thomas C. Brown; second vice-president, A. G. McKean; treasurer, W. A. Hamilton; secretary, David Melville, Collingwood, Ont.; director and superintendent, Joseph P. Welsh; director, W. H. Habgood.

Gowganda

Barbara Mine.—The Barbara Mine consists of six claims, S.W. 6, S.W. 7, S.W. 8, S.W. 9, G.G. 4108 and G.G. 4109, situated on the north shore of Irene or Flatstone lake, in the Gowganda area. The claims are owned by Edmund B. Ryckman, K.C., Toronto, and George R. Rogers, Wigwam, Ont.

Camps have been built and a 25 h.p. Jenckes vertical boiler and a 6-inch by 8-inch Jenckes hoist set up. The underground workings on February 10th, 1916, consisted of a two-compartment shaft sunk to a depth of 100 feet and cross-cuts on the 100-foot level to a distance of 52 feet west and 8 feet east of the shaft.

George R. Rogers is manager, and had nine men employed at the above date.

Bishop.—The Bishop Silver Mines of Canada, Limited, are working Claim L. O. 313, situated on the east side of Calcite lake.

An adit has been driven from the shore of Calcite lake eastward 246 feet. At a distance of 216 feet from the portal, drifting has been done 464 feet north and 127 feet south on a vein in which native silver has been found at several points. All the work is in diabase.

The officers are:—President, Stuart Lindsley, Orange, N.J.; treasurer, C. S. McKune, New York; secretary, George Rosendale, New York. Head Office: 409 West 55th St., New York.

Eight men are employed under superintendent Wm. J. Shields, Wigwam, Ont.

Crews-McFarlan.—The Crews-McFarlan Mining Company, Limited, own mining claims G.G. 3927 and G.G. 3937, situated west of Hewitt lake in Milner township in the Gowganda area. The officials of the Company are:—President, Wm. McFarlan; secretary, H. R. Crews; treasurer, C. H. Streit; all of Patterson, N.J.; manager, Thos. F. Malloy, Gowganda, Ont. The head office is Room 104, Colt Building, Patterson, N.J.

Camps and a blacksmith shop have been built and a two-compartment shaft was started on claim G.G. 3927 on November 1st, 1915. This shaft was 70 feet deep on February 11th, 1916, when the property was visited. A horse whim was in use and 12 men were employed.

Hewitt Lake.—The Hewitt Lake Mining Syndicate continued work on their property in Milner township during all of 1915 and closed down on Jan. 3, 1916. Drifting was continued on the 300-foot level of the main shaft and a new shaft, known as No. 2, was sunk 70 feet.

The officers are:—President, T. B. Clevenger, Rochester, N.Y.; manager, M. F. Cottrell, Gowganda, Ont.

Miller Lake-O'Brien.—The above mine worked all of 1915. Work is now confined to No. 2 and No. 7 shafts. At No. 2 considerable drifting was done on the 140 and 350-foot levels and stoping was carried on above the 140, 240 and 350-foot. At No. 7 shaft, which is 200 feet deep, a winze is being sunk at the end of the east drift on the 200-foot level.

J. G. Dickenson, Cobalt, is manager and B. C. Crowe, Gowganda, Ont., superintendent. At the time of last inspection 78 men were employed.

Powerful.—The Powerful Development Company started work in June, 1915, on mining claim H.R. 397, situated in Lawson township near the west boundary.

This claim was first worked by the Powerful Mining Company. In the summer of 1914 the Oliver Silver Mining, Limited, took a lease on the property but worked for only three weeks. In 1915 the Powerful Development Company acquired the Oliver lease.

The machinery on the claim consists of a Leonard boiler, 80 h.p.; a Laidlaw-Dunn-Gordon compressor, 14" x 14" x 12"; a Jenckes hoist, 6" x 8".

The following is a statement of the underground work done to February 14th, 1916:—

A tunnel runs north-east into a hill and 900 feet of crosscutting and drifting has been done on this level. From the east end of the tunnel a raise 158 feet long at an angle of 45 degrees has been driven to the surface. A winze has also been sunk near the face of the tunnel. It is 145 feet deep and is vertical for 90 feet and inclined at 70 degrees for the remainder of the distance. From this winze three levels have been opened up and the following work done:—At 50 feet below the tunnel level about 75 feet of drifting and crosscutting; at 90 feet below tunnel level, 400 feet of drifting and crosscutting and 30 feet of raising; at 145 feet below tunnel level, 85 feet of drifting.

The officers of the Development Company are:—President, O. Champeau, chief of police, Montreal; secretary-treasurer, J. A. Bonneville, Montreal; manager, Oliver Deschamps, Wigwam, Ontario; head office, 709A Power Building, Montreal.

Reeve-Dobie.—The Reeve-Dobie silver property, comprising claims S.W. 3, S.W. 4 and S.W. 5, west of Gowganda lake has been purchased by the following gentlemen:—A. J. Skobba, Minneapolis, Minn.; Chas. Moore, Bay City, Michigan; F. C. Moore, Sudbury, Ont.; S. Christopherson, Gowganda, Ont.

Work was started in December, 1915. Up to the date of last inspection (Feb. 11th, 1916) the work done by the new management was confined to extracting high-grade silver ore from an open-cut a few feet east of the power plant. Eight men were employed under Mr. Christopherson.

Lorrain and South Lorrain

Bellellen.—On claim R.L. 470, South Lorrain, work was resumed in September, 1915, by the Bellellen Syndicate. On the 100-foot level, about 100 feet north of No. 2 shaft, a winze has been sunk 75 feet. On the 40-foot level of this winze 30 feet of drifting has been done and at the bottom of the winze a drift extends to the south a distance of 125 feet.

Chas. A. Richardson, Haileybury, is manager and Sylvester Carroll, mine foreman. About 15 men are employed.

Currie.—The Currie mine on claim H.R. 105 in South Lorrain was worked continuously in 1915 by the Pittsburg Lorrain Syndicate.

The shaft has been sunk 275 feet on the slope, the first 175 feet is at 45 degrees and the remaining 100 feet at 85 degrees. On the 4th or 175-foot level a winze was started about 500 feet southeast of the main shaft and was sunk for 115 feet

at 80 degrees. Levels were opened off the winze at 50 and 100 feet and by February, 1916, the drifting done on these winze levels was: On the 50-foot, 50 feet to the north-west and 50 feet to the south-east; on the 100-foot, 20 feet to the north-west and 75 feet to the south-east. A No. 1½ special Sirocco reversible fan is used for ventilating the winze workings.

Just above the winze a body of high-grade ore was encountered. The shoot is about 60 feet long and north of the winze it extends to a known height of 85 feet above the level, while south of the winze it runs for 40 feet above. It is in the Keewatin series just above the Keewatin-diabase contact.

Thos. B. Rice, Silver Centre, is superintendent, and Mr. J. A. Rice, 208 Mills Bldg., El Paso, Tex., consulting engineer. The syndicate employ 25 men.

Giroux Claim.—On a claim situated on the north shore of Latour lake, Concession 2, Lorrain township, a shaft has been sunk to a depth of 50 feet and 24 feet of crosscutting done on the 50-foot level. The claim is owned by Fred Giroux.

Keeley.—The Keeley mine was worked by the Associated Gold Mines of Western Australia from May to Oct. 1st, 1915. The work performed consisted of 59 feet of drifting from No. 1 shaft and 328 feet from No. 2.

Dr. J. M. Bell, 310 Dominion Express Building, Montreal, was managing director, and J. G. Harkness, Silver Centre, Ont., mine superintendent.

Tallen.—On Claim H.R. 106, South Lorrain, the Tallen Mining Company, Limited, has sunk a two-compartment shaft 200 feet. On the 200-foot level a drift is being run N. 40 degrees W. In February, 1916, the face of this drift was 200 feet from the shaft. Eight men are employed.

All the work done in this shaft is in diabase with the exception of the last 20 feet at the face of the above-mentioned drift, which is in Keewatin.

The officers of the company are:—President, C. Ferguson, McDonald, Pa.; consulting engineer, J. A. Rice, El Paso; superintendent, Thos. B. Rice, Silver Centre, Ont.

Maple Mountain

Rubicon.—On the property of the Rubicon Silver Mining Company, Limited, in Whitson township, the shaft was sunk to 100 feet and 14 feet of crosscutting was done to the south of the shaft at the 100-foot level. Work ceased in March, 1915.

The officers of the company are:—President, M. J. Morrison, K.C.; secretary-treasurer, E. J. F. Markgraf, Montreal; manager, S. J. Callaghan, Montreal; head office, 180 St. James Street, Montreal.

Taylor.—On mining claim, H.S. 574, on the south shore of McKenzie lake, Speight township, a shaft was started in July, 1915. On February 14th, 1916, this shaft was 155 feet deep and 25 feet of crosscutting had been done on the 150-foot level.

The claim is owned by E. O. Taylor, 244 St. George Street, Toronto. The underground work is being done by L. Peterson, Elk Lake, under contract. Nine men are employed.

White Reserve.—The White Reserve property in the Maple Mountain district is owned by the White Reserve Mining Company, Limited, which has an authorized capital of $200,000 in shares of $1.00 par value each.

During 1915 about 200 feet of drifting was done upon one vein and 30 feet of sinking on another. A prospecting shaft has been sunk to a depth of 35 feet on a third vein. Surface prospecting has been continued to date (May, 1916). The plant has not been in operation since September, 1915, all work since that month being done by hand.

J. A. McAndrew, Lumsden Building, Toronto, is managing director.

IV.—EASTERN ONTARIO

Iron Pyrites

Caldwell.—On lots 1 and 2, in the first concession of Blithfield township, Renfrew county, T. B. Caldwell, of Lanark, is developing a deposit of iron pyrites.

Work was commenced in the spring of 1916, and on the date of inspection in July an incline shaft had been sunk on the vein to a depth of 60 feet. The walls are well defined and from foot to hanging walls there is an average width of 8 feet, and the shaft has been carried 12 feet in width.

A short siding has been built about four miles north of Flower station, on the K. & P. ry., and eventually this will be used as a shipping point when the road to the mine is completed. The plant consists of an 18 h.p. upright boiler, one single drum hoist and guyed derrick.

There are several outcrops on the strike of the vein, east and west of the main shaft, and in the proposed development of the property a station will be cut at the 70-foot level and drifts run east and west to decide the extent of the vein in length. Two cars of ore were shipped as a sample lot from shallow workings, and hauled out before the spring break-up.

Twelve men were employed under superintendent, Samuel Jackson.

Nichols Chemical Company.—The pyrites mine and acid plant operated by the Nichols Chemical Company, a subsidiary of the General Chemical Company, are situated at Sulphide, on lot 23, concession XI, township of Hungerford.

Work in the mine during 1915 was confined to stoping on the north vein and drifting about 250 feet on the new south vein. The main shaft is now 575 feet deep.

Mention has been made in previous reports of the splendid and successful efforts made by the management of this company along the lines of accident prevention and emergency treatment of minor injuries.

During the year 1915, although the working force was trebled, necessitating the employment of unskilled and inexperienced men, the accident rate showed a decided decrease.

At the plant a new brick wash and bath house was erected, containing lavatories, shower baths, etc. Later a similar building will be erected at the mine.

W. H. DeBlois is manager, employing 35 men at the mine and from 125 to 150 at the chemical plant.

Queensboro Mine.—This mine is situated near Queensboro, in the township of Madoc, and is owned and operated by the Canadian Sulphur Ore Company. During 1915 the main shaft was sunk to a depth of 307 feet, and stoping continued on the east and west ore bodies.

The only addition to the plant during the year was one small Marsh and Henthorn hoist, for handling cars on the incline from the crusher bins to the railway. A new 7 drill compressor will be installed early in 1916 to take care of the proposed development work.

The officers of the company are:—Alex. Longwell, president; Geo. H. Gillespie, manager; W. Coleman, superintendent; and 45 men were employed throughout the year.

Iron

Canada Iron Mines, Limited.—There was no production of iron ore in eastern Ontario during 1915. Both the mine at Bessemer and the concentrator at Trenton owned by the Canada Iron Mines, Limited, were closed during the year.

Early in the year 1916 the company shipped 15,000 tons of magnetic concentrates to Buffalo. This shipment averaged: iron (natural), 55, and phosphorus, .020 per cent.

No definite arrangements for 1916 operations have been made, but it is highly probable that the Hastings County mines will be opened up in the spring. The officers of the company are:—F. B. Richards, president; A. W. Holmestead, secretary, and W. J. McLaughlin, manager.

Gold

Cordova.—In the Twenty-Fourth Annual Report of the Bureau of Mines a full description is given of the many improvements and additions to the plant at Cordova mine, made during the last half of 1914 and the early part of 1915. In April, 1915, the mine was closed for the balance of the year.

Peter Kirkegaard is managing director of the operating company, known as Cordova Mines Limited.

Golden Fleece.—The Golden Fleece Mine is situated on the west half of lot 24 and on lot 25 of the sixth concession, township of Kaladar. The property was described in the Twenty-Second Annual Report of the Bureau for 1913, and at the time was being operated by the A. B. P. Mining company. Late in 1915 it was acquired by the Cobalt Frontenac Mining company. The old workings were dewatered and sampled and preparations are being made to place the mine on a producing basis.

No. 1 shaft is 85 feet deep, with a station cut at 61 feet. At this level a drift runs to the north 66 feet, with 21 feet of crosscutting.

No. 2 shaft is 40 feet deep.

The plant from the Cobalt Frontenac mine at Elk Lake has been transferred to the Golden Fleece. D. H. Fletcher, Hamilton, is president of the operating company, and the work at the mine is in charge of E. Craig. The post office of the mine is Flinton, about two miles distant.

Ore Chimney.—The Ore Chimney Mining Company, Limited, continued to develop its property in Barrie township during 1915. At the close of the year the development to date was as follows:—

Shaft, depth 340 feet.

1st level at 108 feet, east drift 17 feet, south drift 6 feet, and crosscut 25 feet.

2nd level at 150 feet, north drift 107 feet, south drift 79 feet, and total crosscutting 78 feet.

3rd level at 250 feet, north drift 83 feet, south drift 100 feet, and total crosscutting 237 feet.

4th level at 300 feet, crosscutting 31 feet.

5th level at 332 feet, crosscutting 44 feet.

Stations have been cut at the first three levels. A new safety cage has been installed and the 20-stamp mill mentioned in the last report has been erected. The stamps only are in place, but it is the intention of the management to add a magnetic concentration process. The gold values will be recovered by amalgamation, but the process for the zinc and copper values has not yet been decided. During the year a small assay laboratory was installed. The mine closed down in December, 1915, and it is expected that operations will be resumed in March, 1916.

No ore was shipped from the property during the year.

From 30 to 40 men were employed throughout the year. The officers of the company are:—D. E. Fletcher, president, Hamilton; Chas. Narraway, secretary, Hamilton, and W. G. Anderson, manager, Northbrook.

Ore Mountain.—The Ore Mountain Mining Company, Limited, continued to prospect its property on lot 32, concession I, Barrie township. The original shaft was abandoned and a small amount of work done at other points on the property. The Pay Ore Mines, Limited, and Ore Extension Mining Company were closed throughout the year.

Talc

Connolly Mine.—The Connolly talc mine is situated near the village of Madoc and adjoins the Henderson mine on the east. During the year the Anglo-American Talc Corporation, Ltd., was formed and took over the lease held by the former operators. Development work was continued and the shaft sunk to a depth of 140 feet—with levels at 65 feet and 130 feet.

A grinding plant is in course of erection at the mine and a building 100 feet by 30 feet has been erected.

The officers of the corporation are:—H. S. Predmore, president, New York; R. J. Gilchrist, secretary, New York; Thomas Carswell, superintendent, Madoc.

Eldorite Limited.—Eldorite Limited, formerly the Canadian Talc and Silica Company, worked intermittently during the year. The work was under the direct supervision of J. A. Haig, representing the principal owners. Further changes were made in the grinding plant, and it is expected that in 1916 this property will be a steady producer. Robert Phillips was succeeded as superintendent by R. C. Millington.

Gillespie Mill.—Messrs. George H. Gillespie and Company operated their talc grinding plant steadily during the year. This company purchases its supply of talc from Messrs. Cross and Wellington and takes about 90 per cent. of the output of the Henderson mine. The plant was described in the Twenty-Fourth Annual Report, and remained the same, with no additions during 1915. Twenty-five men are employed.

Henderson Mine.—This property, near the village of Madoc, has been described in successive Annual Reports of the Bureau of Mines, and is one of the largest producers of pure white talc in the world.

It is operated under lease by Messrs. Cross and Wellington, of Madoc. During the year 1915 work was confined to the sub-level drift through caved material between 1st and 2nd levels. This drift when completed will connect the two shafts. The output of the mine was greater than in any year since the mine was opened. S. Wellington is in charge of the mine, employing an average of 10 men.

Fluorite

On lot 11, concession XIII, in the township of Huntington, known as the Perry lot, Messrs. Cross and Wellington are developing a deposit of fluorite. The vein varies from 1 to 3 feet in width and has been stripped a distance of 200 feet. Near the Madoc-Belleville branch of the Grand Trunk a shaft is being sunk which was down 25 feet when inspected on February 9th, 1916. About 100 tons of fairly clean spar had been produced from this shaft, and stock-piled near the siding.

On lot 10, concession XIV, of Huntington, known as the Rogers lot, Messrs. Cross and Wellington have pumped out the old workings and are preparing to resume sinking operations. A syndicate headed by C. M. Bowman did some work on this lot in 1914, and sunk the shaft to a depth of 65 feet.

There are several known deposits of fluorite near Madoc, and it is quite possible that the coming year will see considerable activity in this district. The fluorspar is apparently of high grade, and the work now being done will demonstrate the importance of the deposits.

Lead

Galetta Mine.—This property was described in Volume XXIV under the name of the Kingdon mine. It is owned by the Estate James Robertson, Limited, Montreal, and for descriptive purposes may be called the Galetta mine. It is located on lot 22, in the sixth concession of the township of Fitzroy, on Chats island, about two miles west of the village of Galetta, and five miles directly east of the town of Arnprior.

Since last Report very little work has been done underground. The shaft remains the same depth, 112 feet. A winze is being sunk in the west drift about 160 feet from the shaft, and on August 8th, 1916, the winze was down 30 feet in good ore. At the same time stoping was in progress on the main vein, west of the shaft, with two hammer-drill crews.

The mill mentioned in last Report was completed in August, 1915, and the ore on the dump milled in addition to the small amount hoisted. A new double drum, electrically operated, Flory hoist, and a two-stage Ingersoll-Rand compressor, 1,500 feet capacity, have been installed.

On the date of inspection excavating was in progress for a smelter to be erected near the mill. A. G. Munich is manager for the James Robertson Estate, employing 70 men.

The geology and character of this ore deposit is very fully described in Dr. W. L. Uglow's report on the Lead and Zinc Deposits of Ontario, being Part II of the Twenty-fifth Annual Report of the Ontario Bureau of Mines, 1916.

Feldspar

Canadian Feldspar Corporation, Limited.—During 1915 a considerable tonnage of high-grade spar was mined by the above company on lot 4 in concession X, township of Portland. The property is located about 2½ miles west of the village of Verona on the Reynolds farm.

On the date of inspection in September, work was in progress in an open pit measuring 40 feet long, 35 feet wide and 40 feet deep. The spar was mixed with quartz in places, and most of the product had to be cobbed before shipment. L. E. Austin is manager of the company, and H. A. Hawley sceretary-treasurer. Twenty men were employed.

Hurlburt.—On lot 1, con. XI, township of Loughborough, George Hurlburt, of Toronto, is developing a feldspar property formerly owned by L. E. Austin. Several test pits have been sunk and fairly clean spar exposed in places. Work was started on this lot on March 20th, 1916, and a small boiler and hoist installed. During the summer of 1916 Mr. Hurlburt expects to do considerable stripping where the dike shows the highest grade spar, and the product will be stock-piled at the mine in readiness for the winter haul to Verona. George Hurlburt is in charge of operations, employing six men; post-office address, R.R. No. 1, Hartington.

McIntyre Prospect.—A small quantity of feldspar was extracted in 1915 from a deposit in the District of Muskoka, on the McIntyre farm, lots 26 and 27, con. II, Stephenson township. The deposit occurs in gneiss. At the time of inspection, July 15th, 1915, Stewart W. Hall, of 118 Barton Ave., Toronto, had taken out nearly a carload of feldspar and hauled it 2½ miles west to Metler siding for shipment.

Richardson Mine.—Owing to the destruction by fire of the grinding plant at Charlotte, New York, the Kingston Feldspar and Mining Company was not able to ship until late in the season of navigation. The spar was stock-piled at the mine and a large tonnage shipped by rail to potash plants. The company also own a large amount of high-grade spar in stock at Verona station on the C. P. railway, the output of the Reynolds mine.

Considerable stripping was done at the Desert Lake mine in the south end of the pit. At this point there is a heavy over-burden of clay, in places 30 feet deep, and it is believed that the spar extends a considerable distance in this direction.

The plant and method of mining remained same as in previous reports.

H. W. Richardson, Kingston, is manager of the company, employing 55 men throughout the year.

Victoria Feldspar Quarry.—On the north half of lot 32, and all of lot 33, in the third concession of Bedford township, Messrs. J. M. Stoness & Sons opened a feldspar quarry late in 1915. The spar is unsuited for use in the manufacture of pottery, but contains about ten per cent. of potash and will be sold to the fertilizer trade. One car was shipped in 1915, and two cars in March, 1916, and it is the intention to work on a large scale, when a spur line to the Canadian Pacific railway is completed. This spur is 584 feet long and is now graded for that distance. The property is located about three miles west of Crow Lake station, and is practically cut in two by the new lake shore line of the C. P. Railway. It is the intention of the owners to erect a grinding plant at the property.

Mica

Anglin Mine.—In October, 1915, the Anglin Mica Mining Company acquired the mining rights to 200 acres, being part of lot 10 in the tenth concession of the township of Loughborough. This is a promising prospect and has already produced about 30,000 lbs. of mica. The mica is rough cobbed at the mine and shipped to the trimming works at Kingston recently erected by the company. Fifteen men are employed at the mine under J. E. Anglin.

Grierson and Gallagher.—On lot 4, about three miles west of Oliver's Ferry, on Rideau lake, Messrs. Grierson and Gallagher, of Perth, are operating a mica mine, leased from Edward Smith. Six men are employed and a fairly large production has been maintained since September, 1915. Most of the product is sold to S. H. Orser and Company, of Perth.

Lacey Mine.—This mine in Loughborough township, near the village of Sydenham, continued to be the largest producer of mica in the Province. Most of the product in 1915 came from the Milky vein, which is now being stoped. This vein was discovered by crosscutting from the old workings a distance of 60 feet, and has been a steady producer for the past three years. The stope measures 100 feet long, 75 feet to the back, and has been carried on at an average width of 18 feet. The main shaft is 185 feet deep, with workings on seven levels. The output during 1915 was somewhat curtailed owing to the restricted operations of the largest consumers. There was a good demand for the smaller sizes, 1 in. by 1 in. and 1 in. by 2 in. Old dumps supplied the demand for 1 in. by 1 in., the splittings of which may be built up to any required thickness by the use of a shellac binder.

It is interesting to note that the Lacey mine has produced in the past 15 years over 10,000,000 lbs. of closely rough cobbed mica. Prevailing average prices received in 1915 were as follows:—

1 x 1	5 cents.	2 x 4	50-55 cents.
1 x 2	10 cents.	3 x 5	60-75 cents.
1 x 3	16 cents.	4 x 6	80 cents-$1.00
2 x 3	32-35 cents.		

George W. McNaughton is manager of the mine, employing from 11 to 15 men.

Sidney H. Orser Mica Company.—In the vicinity of Perth, in the townships of Burgess and Bathurst, S. H. Orser and associates have done considerable prospecting for mica, and also operate a mica cleaning house in Perth.

During 1915, Mr. Orser operated a property under lease from Edward Stafford. This prospect is located in concession VI of Bathurst township, near Bennet lake. A pit measuring 12 feet by 5 feet by 20 feet deep was sunk, and about 12,000 pounds of rough cobbed mica produced. About three miles west of Oliver's Ferry on the shore of Rideau lake, in the township of North Burgess, Mr. Orser operated an old abandoned mine, under lease from Messrs. Webster and Stewart, of Perth. This mine was in early days a large producer of phosphate, and a small amount of work developed a considerable quantity of mica. The option expired in June, 1915, and no work has been done since that date. On lot 6 in concession VIII of Burgess, about six miles south of Perth, Mr. Orser began operations in January, 1916, on what was formerly known as the Burns mine. An old pit 45 feet deep has been cleaned out, and is being timbered and lagged over. A vein of mica about six feet in width has been uncovered. Adjoining this property on the west half of lot 3 in concession VI of Burgess, Mr. Orser and associates expect to commence work about May 1st, 1916. A small plant has been purchased for this property, all the others being worked with hand steel and horse whim.

Scott Mine.—This prospect, on lot 7, concession 9, Bedford township, was discovered and originally operated by Scott Bros., of Bedford. By them it was transferred to the Anglin-Stonness-Gilbert Mica Company, who operated it in 1914. During 1915, the holdings of this latter company were taken over by the Anglin Mica Mining Company, Limited. The Scott property was worked for three months in 1915, then closed down, and the force of 15 men transferred to the Tett lease. This lease was operated for four months and produced about 15,000 lbs. of cobbed mica.

The headquarters of the company are at Kingston, and the officers are: S. Anglin, president; J. E. Anglin, vice-president and manager; F. R. Anglin, secretary, and C. S. Anglin, treasurer.

Taggart Mine.—This mine is situated on the west shore of Bobs lake, in Bedford township.

In 1915 it was worked with a small force from September to the end of the year. The product is trimmed and finished for the market at Kingston by Kent Bros. J. M. Stoness is manager.

Trimming and Splitting.—The following firms are engaged in trimming and thin splitting mica: At Ottawa, General Electric Company, Laurentide Mica Company, S. O. Fillion, Eugene Munsell and Company, and R. Blackburn; and at Kingston, the Anglin Mica Mining Company and Kent Bros. are operating.

Molybdenite

In the Twenty-fourth Annual Report of the Bureau of Mines a complete summary is given of the sources of molybdenum ores in the British Empire and their uses in steel making and in the various arts and industries. Due to this demand from England and the information given by the Director of the Imperial Institute of London, considerable activity was shown throughout the year in exploiting known deposits of this mineral and prospecting in likely territory. In eastern Ontario molybdenite has been found in the counties of Haliburton, Lennox and Addington, Frontenac and Renfrew.

A considerable quantity of almost pure hand-picked crystals was shipped, but the amount recovered in this manner formed only a small percentage of the total content in the ore, and concentration methods had to be developed.

Concentrators.—(1.) G. C. Mackenzie, of the Mines Branch, examined most of the deposits for the Dominion Department of Mines, and several trial shipments were made to the testing plant at Ottawa. A workable process was finally evolved giving a good extraction. Custom ore is being treated and concentrates shipped to England.

(2.) The Orillia Molybdenum Company was formed in 1915, to mine, concentrate and refine ores of molybdenum. Early in the year the company purchased the Jamieson molybdenite prospect near Eganville, county of Renfrew, and in addition to the production from this property have purchased custom ores from other properties. The plant erected at Orillia by the Canadian Smelting and Refining Company was taken over and part of it utilized for experimental work on molybdenite ores. A process finally was worked out which the company state is quite successful. At the close of the year the concentrating plant had a capacity of twenty tons per day. The company shipped a small quantity of concentrates, but most of the product is being shipped in the form of molybdic acid. Further experimental work is in progress, and by April 1st, 1916, the company expect to be producing ferro-molybdenum.

The officers of the company are: President, G. P. Grant; manager, F. G. Cross; metallurgist, B. C. Lamble; manager ore department, J. F. McKenzie, and mine superintendent, J. G. Sipprell.

The following tariff of treatment charges is in effect at the Orillia works of the company:

TARIFF OF TREATMENT CHARGES.

Ore or concentrates over	10%	MoS_2	—	$15.00	per ton	—	85%	recovery
Between	8-10	"	—	14.50	"	—	"	"
"	7-8	"	—	13.50	"	—	"	"
"	6-7	"	—	12.50	"	—	"	"
"	5-6	"	—	11.50	"	—	"	"
"	4-5	"	—	10.50	"	—	"	"
"	3-4	"	—	9.50	"	—	"	"
"	2-3	"	—	8.50	"	—	"	"
"	1½-2	"	—	7.50	"	—	80%	"
Under	1½	"	—	No tariff, and only treated subject to special terms to be made on each shipment.				

Settlement is made at the rate of $1.00 per lb. of MoS_2 within 21 days after date of sampling.

No credit is allowed for any molybdic oxide present in ore—all samples must first be leached with ammonia to remove any oxide present. Special penalties dependent upon character of ore for presence of copper, bismuth or arsenic.

(3.) W. J. Spain, of New York, purchased the Legree prospect in Renfrew county and, after considerable development, decided to erect a concentrating plant at the mine. In all, the production end was placed on a fairly substantial basis during the year, and developments during 1916 will be awaited with interest.

Belgian Syndicate.—In 1914, a group of capitalists with head office in Brussels, Belgium, started operations on a promising molybdenite discovery, on lots 7, 8 and 9, in the 11th concession, and lot 8, in the 12th concession of Brougham township. An adit was driven 75 feet and the ore body prospected with about 150 feet of drifting.

When inspected in October, 1915, the camps were being prepared for a renewal of operations which were suspended when war was declared.

The directors of the company, formerly known as the Algunican Development Company, which in 1915 was succeeded by the Renfrew Molybdenum Mines, Limited, included Jean Vanophen, A. E. Goyette, P. C. Neault, and Victor Mienwenhuyse, with Horace Young as Canadian manager.

Burns Prospect.—On lot 4, in the 15th concession of Sheffield township, H. C. Bellew, of Montreal, began work in September, 1915, developing a molybdenite prospect on the Burns farm. This property is situated near the Chisholm prospect, about seven miles south of the village of Enterprise. Trenching and stripping was in progress on the date of inspection.

Cailloux Prospect.—On lots 8 and 9, in the 15th concession, and on lot 11, in the 12th concession of Sheffield township, L. L. Cailloux, of Montreal, started work about September 1st, 1915, developing molybdenite prospects on the Spratt and Oderdike farms.

On the date of inspection, a fairly good deposit had been discovered on the Spratt farm and work was in progress in an open cut, measuring 30 feet by 25 feet and by 20 feet deep. Five men were employed by Mr. Cailloux.

Jamieson.—This prospect is situated on lots 5 and 6, in the 8th concession of Lyndoch township, and was originally owned by the Jamieson Bros., of Renfrew. Early in 1915 it was acquired by the Orillia Molybdenum Company, and worked by them throughout the year. At this prospect there is a fairly well-defined vein running about 5 degrees east of north, which has been open cut for a distance of 220 feet. The average width of the open cut was 21 feet, and average depth 21 feet. The pit measured 24 feet at the deepest point. Substantial boarding camps, office, stables and shops were built during the year, and preparation made for operating on a larger scale if conditions warranted. The ore was hoisted by a stiff leg derrick, 35-foot boom, and dumped on a platform, where the pure crystals were picked out and shipped separately. By careful hand cobbing a 20 to 30 per cent. product was secured, for shipment to the company's smelter at Orillia.

Up to October 5th, 1915, 80 tons had been shipped, of which about 2 per cent. was pure leaf. Forty men were employed. The officers of the company are:—J. B. Tudhope, president; J. F. McKenzie, manager, and J. G. Sepprell, superintendent.

Legree.—On lots 35 and 36, in the fourteenth concession of Brougham township, county of Renfrew, Joseph Legree, of Renfrew, is developing a molybdenite prospect. The occurrence is practically the same as at the Spain and Jamieson properties. The ore body has an average width of four feet, and the molybdenite is closely associated with sulphides in the gangue.

O'Brien.—A number of molybdenite discoveries were made in the township of Brougham by Joseph Charron, of Renfrew, who, in conjunction with Dr. Connolly, held the mining rights on several lots, including lots 15, 16, and 17, in the 11th concession, and lot 16, in the 10th concession. These were divided up and transferred in part and otherwise.

On parts of the above lots is situated the O'Brien prospect, owned by M. J. O'Brien, of Renfrew. In October, 1915, J. C. Murray took charge of this property, and it developed into a steady shipper of ore running from 3 to 6 per cent. MoS_2.

The ore body runs east and west, and ore has been found over an area of 1,000 feet in length by 100 feet in width. Substantial buildings have been erected, including cook camp, ore sorting house, sleep camp, stables and shops.

The ore is hauled twelve miles to Ashdod station, on the C. P. railway, and shipped to the Orillia smelter for treatment.

The postoffice of the mine is at Dacre R.F.D. No. 1.

J. C. Murray is in charge of the property, employing twelve men.

Orr.—About ten miles southeast of the village of Wilberforce, in the 5th concession of Cardiff township, Fred. O. Orr, of Peterborough, discovered molybdenite and did a small amount of development work. The molybdenite occurs in small flakes through the capping of gneiss. Several test pits were sunk, but at no point was the showing sufficient to warrant further work. Mr. Orr also prospected several adjoining lots, but on the date of inspection, October 14th, no work was in progress.

Paterson.—On the west half of lot 28, concession 4, Bagot township, Mark J. Paterson, of Toronto, did considerable development work on a molybdenite prospect.

The ore occurs in the usual manner over a large area, which had been stripped 35 feet in width, over a distance of 400 feet. At one point a pit was sunk 20 feet deep and from this some 4,500 lbs. of pure flake molybdenite had been shipped.

Work was in charge of Mr. Paterson, but had been discontinued on the date of inspection, October 7th.

Richardson Prospect.—On lot 22, in the second concession of Ross township, Renfrew county, a promising molybdenite prospect has been opened up on the John Rose farm by Thomas E. Richardson, of Portage du Fort, Quebec. The property is reached by good wagon road and is convenient for shipping, being situated

about one mile southwest of Haley station, on the main line of the Canadian Pacific Railway. The mineral occurrence differs somewhat from others in the district, in that the ore occurs in a well defined quartz vein, having an average width of five feet. On the date of inspection in April, 1916, a prospect pit had been sunk 35 feet in length by 10 feet deep, and varying in width from 3 feet to 12 feet. The ore is of good quality, and is associated in the quartz with pyrites and feldspar. The prospect will be further developed during the year.

Russell.—Near the village of Norland, on lot 5, concession 11, township of Laxton, Capt. A. J. H. Russell is developing a molybdenite prospect. A vertical shaft 7 feet by 9 feet has been sunk to a depth of 35 feet on the shore of Mud Turtle lake. The molybdenite at this property is disseminated throughout a gangue of pyroxenite and apparently no other sulphides are present. In this respect it differs from the deposits described above in Renfrew county.

This deposit of molybdenite was probably the first discovery of this mineral in the Province. Specimens from lot 5, Laxton township, have been for many years in the old Toronto Museum, and mention was made of this deposit in Sir William Logan's Report.

Sheffield.—On lot 5, of the fourth concession of Sheffield township, county of Addington, A. M. Chisholm, of Kingston, re-opened his molybdenite prospect, which had been lying idle for several years. Mr. Chisholm owns the mineral rights on 50 acres, and did considerable work in 1904 and 1905 on this prospect.

The ore occurs in crystals of various sizes, disseminated in a gangue of pyroxene, pyrrhotite and iron pyrites. At the Chisholm property there appears to be several distinct mineralized zones with a fairly definite strike N.E. and S.W. Mining is carried on in an open pit, which on the date of inspection in September, measured 80 feet long by 80 feet wide, with an average depth of 20 feet. The plant included one guyed derrick with a single-drum March and Henthorn hoist and 15 h.p. upright boiler.

Twelve men were employed under the direct supervision of Mr. Chisholm, the owner of the property.

Snake Lake.—On the west half of lot 28, in the 12th concession of Bagot township, on the shore of Snake lake, near the boundary line between Bagot and Blythfield townships, R. R. Gamey did some prospect work on molybdenite showings. The work consisted of trenching and sinking test pits, under the direction of W. J. Urquhart.

Spain.—On lot 31, in the 4th concession of the township of Griffith, W. J. Spain, of New York, did considerable development on what was known locally as the Legree prospect. This discovery was made on property owned by Joseph Legree, of Renfrew, and by him transferred to Mr. Spain in the spring of 1915.

A plant was installed consisting of one Wicker double drum hoist, one 60-h.p. Nagle boiler, portable locomotive type, pump and derrick. On the date of inspection in September, ore was being taken from an open pit, measuring 75 feet long by 50 feet wide, and with a depth of 15 feet at the deepest point. A vertical shaft

7 feet by 8 feet had been sunk to a depth of 35 feet. About six tons of pure leaf molybdenite had been shipped to various firms in the United States, and another ton was in cases ready for shipment. On dump at the mine, between 400 and 500 tons of ore running 4 per cent. MoS_2 was stock piled for treatment.

On account of the long haul to the railway, Mr. Spain decided to erect a concentrating plant at the mine. Construction work had not been started, but plans for the mill followed closely the process developed at the testing plant in Ottawa. The original design included jaw crusher, cylindrical drier, 3 sets rolls, Newago screens of various sizes, two 30-foot picking belts, one 10-ton roaster, and 4 water flotation units.

George Gray was in charge of the work, employing 20 men.

Treasure Hill Mine.—This property is situated on the Alex. Evans farm, near Cheddar postoffice, in Cardiff township, about ten miles south of the village of Wilberforce. Molybdenite was discovered here by Messrs. Elliott and Bolmer. From November, 1913, to March, 1914, it was worked under option by M. J. O'Brien. A vertical shaft was sunk to a depth of 35 feet, and several test pits sunk in various parts of the property. A small plant was installed, including a 50 h.p. locomotive type boiler, Wettlaufer crusher and a set of 12-inch rolls.

The ore occurs with pyrites in a schist gangue. No work has been done since March, 1914.

Warren.—On the west half of lot 27, in the 4th concession of Bagot township, Renfrew county, R. R. Gamey had the mineral rights on the Warren farm under option.

Work was started September 1st, 1915, under the direction of W. J. Urquhart, of Toronto, and seven men were employed in trenching and sinking test pits. Molybdenite occurs on this lot in connection with the sulphides of iron, under a capping of gneiss about 8 feet in thickness. No shipments had been made from this property up to October 7th, 1915.

Wilson.—In the township of Matawatchan, on lots 3 and 4, near Wilson postoffice, and close to the boundary of Miller township, there is an occurrence of molybdenite on the farm owned by James Wilson. Very little work has been done on this prospect at the time of inspection, but the fact that molybdenite occurs in a pegmatite dike extending several hundred feet, would warrant further development.

Graphite

Black Donald.—The Black Donald mine is situated on Whitefish lake, about 14 miles from Calabogie, in Renfrew county. The company's mining rights include lots 17 to 20 inclusive, in concessions 1, 2 and 3, township of Brougham.

Mining operations are generally stopped about November 1st and resumed in the spring, sufficient ore being hoisted in the summer months to supply the mill for the year. In 1915, pumping was commenced on May 1st, and two weeks later hoisting was resumed. It is the intention of the management to keep the mine in operation during the winter of 1915-16 for the first time in its history.

The workings have reached a depth of 145 feet. The winter's supply of ore will be taken from a 10-foot stope starting from the shaft.

During the year there was a largely increased demand for Canadian graphite, due to the interruption to foreign shipping from Ceylon and Korea. A large proportion of the best pencil stock comes from Senora, Mexico, and, due to the revolution in that country, our trade was increased. Foundries running on a 25 per cent. efficiency basis in 1914 were working double shifts in 1916. As a result the Black Donald increased its output of refined graphite by 50 per cent. Large consumers in the United States are beginning to look with favor on the Canadian product, and the outlook for the future is exceedingly bright.

The officers of the company are:—A. H. Munger, president, Kansas City; R. F. Bunting, general manager, Calabogie; and J. N. Snead, secretary, Calabogie. Fifty men were employed under superintendent J. G. Patno.

Globe.—In October, 1915, the Globe Graphite Mining and Refining Company, Limited, was organized and work resumed in the old Globe mine, situated about three miles south of Port Elmsley, in concession 6, township of North Elmsley. This property was worked many years ago and was in early mining days in Ontario known as the Pyne mine. In 1900 it was acquired by Rinaldo McConnell, who formed the Globe Refining Company. For the past three years the mine has been closed, but the increased demand for Canadian graphite, particularly for the flake variety, has again placed it in the producing class.

The mine was first worked by the open-cut method, but work at present is confined to timbering the shaft which is now 125 feet deep, and stoping on the vein at this level. Considerable work will be necessary to clean out old working and place the mine on a safe working basis with an increased production.

The present output is about 30 tons per day of ore running 10 to 12 per cent. flake graphite. The mill at Port Elmsley has a capacity of 40 tons per day, a dry process of refining being used.

The officers of the company are:—President, Rinaldo McConnell; vice-president and manager, H. F. Meech, and secretary, J. L. Wells.

Fifteen men are employed at the mine and twelve at the mill.

National.—National Graphite, Limited, was organized in the spring of 1915, and is an amalgamation of the interests held by Messrs. Matthews and Foster in certain mining lands in Hastings county, and the milling and mining interests of the New York Graphite Company. The latter company owned a large mill at Harcourt on the I. B. and O. railway, and ore from the Matthews mine is shipped to this mill for refining.

The mine is situated near the village of Maynooth, in Monteagle township. The graphite is of the flake variety disseminated in a limestone gangue, and is easily concentrated. The orebody appears to have a definite strike northwest, and is worked by the open-cut method. On the date of inspection, in September, the pit was 40 feet long by 18 feet wide and 25 feet deep.

R. W. Matthews is manager of the company, employing 21 men at the mine and 12 at the Harcourt mill.

Corundum

The Manufacturers Corundum Company operated its property in Carlow township, Hastings county, for the first two months of the year. The mine and mill at Burgess were closed March 1st, and nothing was attempted in the line of production at this property for the balance of the year. Some diamond drilling was done on the company's holdings on the York branch of the Madawaska river and small shipments made for testing purposes. D. A. Brebner, president of the company, states that nothing will be done till the results of these tests are known.

Marble

Ontario Marble Quarry.—Ontario Marble Quarries, Limited, own lots 29 and 30 in the 10th concession of Dungannon township, and lots 41 and 42 in Faraday township. High grade marble of various colors is produced, the chief output coming from No. 1 quarry, pink and green variety, and No. 2 quarry, which produces a pure white marble.

At No. 1 quarry, the plant includes a stiff leg steel derrick, and double-drum hoist, and a Whitelaw 90 h.p. horizontal tubular boiler.

At No. 2 quarry are 2 Sullivan channeling machines, one guyed derrick and 2 upright 35 h.p. boilers. The two workings are connected by a standard gauge railway. At the sawing plant there are 4 sets of gang saws, with 50 saws to the set. The marble from this quarry can be delivered in any size required and in a great variety of colors. It takes a perfect polish and compares favorably with the imported marbles. Thomas Morrison is manager of the company, employing 20 men.

White Marble Co. of Canada, Ltd.—A description was given in the 24th Annual report of the plant and quarry of this company, in the township of Horton, near Haley station, Renfrew county. Operations were carried on till September 15th, 1915, on which date the quarry and sawing plant were closed. J. A. McLaughlin, who was left in charge of the property, stated that operations would be resumed in the spring of 1916, by new interests, allied to the Canada Glass Mantles and Tile Company of Toronto.

Quarries

Britnell and Company.—This Company resumed operations on a reduced scale in their quarry on lot 13, in the 6th concession of Somerville township, Victoria county. No dimension stone was shipped during the year, the product being confined to crushed limestone of various sizes. The plant consists of 4 upright boilers, 15 h.p. each; 3 stiff leg derricks; 3 double drum hoists; one locomotive boiler, 35 h.p.; one Gates breaker, No. 3; screens and bucket conveyers.

Five men were employed on the date of inspection in October, under foreman J. A. Lumby.

Canada Cement.—The Point Anne quarry and plant situated on the Bay of Quinte, about six miles east of Belleville, resumed operations in the spring of 1915,

and closed again in December. The quarry was based on a basis of greater production during the year by improved methods of working. Drilling was kept well in advance of requirements. The average depth of the quarry is now 20 feet. The large 36 by 60-inch Fairmount crusher, installed in 1914, worked satisfactorily.

H. L. Shock is local manager, employing 12 men in the quarry.

Canada Lime Company.—This company is one of the largest producers of pure white lime in the Province. They own lots 37 to 40 inclusive in the township of Somerville, and lots 4, 5 and 6 in the village of Coboconk. One kiln with a capacity of 10 tons per day was operated during 1915, owing to the slack trade. The company's quarry and kilns at Sand Point, near Renfrew, were closed most of the year. Mr. Ballantyne, formerly in charge at Coboconk, moved to the Sand Point property and was succeeded by C. R. Christie, president of the company,

Ten men were employed during the year.

Crushed Stone Limited.—The crushing plant of this company is situated on the Trent Valley canal, on lot 49, in the township of Eldon, Victoria county, near the village of Kirkfield. For a number of years this company has been crushing the material thrown on the bank when excavating for the Trent canal, working under lease from the federal government. The plant consists of one No. 7½ McCully crusher, one No. 4 Gates crusher, two 100 h.p. Goldie-McCullough boilers, elevators and screening plant. All sizes of crushed stone are shipped.

W. H. Essery is president of the company and A. E. Oliphant superintendent, employing thirty men.

Crookston.—Messrs. Quinlan and Robertson began operations for the year at their Crookston quarry on May 10, 1915, and continued throughout the year. The quarry is situated on lot 19, in the 9th concession of Huntingdon township, near Crookston station, on the Madoc branch of the Grand Trunk railway. Most of the material discarded as unfit for dimension stone, the accumulations of many years of steady operations by different owners, was used up during the year and quarrying started in the old workings.

W. E. Tummon is superintendent, employing fifteen men.

Delta Lime Company.—On lot 27, in the 8th concession of Bastard township, the Delta Lime company operated their quarry during the year. The product is a high grade crystalline limestone, which is burned at Delta village. One kiln with a capacity of 150 bushels of lime per day is operated during the summer months. Omar Brown, Delta, is manager of the company.

Eganville Quarry.—The Standard Chemical, Iron and Lumber Co. operated their quarry on a reduced scale during 1915. The quarry and lime kilns are situated near the village of Eganville, on lot 19, in the 20th concession of the township of Grattan. One kiln, with a capacity of 450 bushels of lime per day, was kept in commission.

J. S. Shane succeeded Mr. Arveson as manager during the year. Ten men were employed on the date of inspection in October.

Gosselin.—On lot 22 in the township of Gloucester, on the Montreal road, Charles Gosselin continued to operate his limestone quarry. The plant in this quarry consists of one stiff-leg derrick, one upright boiler, 15 h.p., one Climax jaw crusher, one Case steam thresher engine, elevator, and screens. Crushed stone, rubble, dressed building stone, and dimension stone of all sizes is supplied to the Ottawa trade. Thirteen men were employed on the date of inspection.

Gordon and Son.—During the summer months the firm of Gordon and Son quarried granite near the village of Escott in Leeds county, about 12 miles east of Gananoque.

Large pieces are broken by the plug and feather method, and these subdivided into paving setts, for which the grey granite is admirably suited. Fifteen men are employed.

Kingston.—The quarry owned by the City of Kingston and located on Montreal Street was operated at intervals during the year by Henry MacRow. All of the product was used by the city for street purposes. Some building stone was taken by different contractors from the Division Street quarry, which for many years has supplied the building trade with the high-grade stone to be seen in all of Kingston's public buildings. The penitentiary officials operated their quarry at Portsmouth throughout the year. Convict labor is employed, and the product used in the erection and maintenance of walls and buildings around the prison.

McMillan.—On lot 19 in the 7th concession of the township of Williamsburg, near the village of Dunbar, James McMillan quarries limestone for building purposes. A 12-foot bed of high-grade stone is worked by the plug and feather method, and most of the product is made up into sills and lintels. No plant is required, and operations are carried on in a small way, as the building trade in the locality demands.

Mille Roches.—On lots 24, 25 and 26, in the 4th concession of Cornwall township, there are four large quarries which have been worked at short intervals since 1895. They are situated about two miles west of the village of Mille Roches, near the Grand Trunk railway, and during the construction of the Cornwall canal were large producers of cut stone and crib filling material. The limestone is of good quality, and shipping facilities are excellent.

Messrs. Philip and Urquhart Thompson, James Henderson, and Larkin and Sangster own the several lots.

Ontario Rock Company.—The trap rock quarry owned by this company at Preneveau, near Havelock, in Belmont township, was closed till May 31st, 1915, when operations were resumed and it ran continuously till the close of the year. The working face is now 65 feet deep by 200 feet wide.

The plant consists of one horizontal tubular boiler 100 h.p., one locomotive type 150 h.p., one 175 h.p. Brown mill engine, one No. 8 Austin gyratory crusher, one Jenckes jaw crusher, two Simons disc crushers numbers 24 and 36, one Marsh

and Henthorn 7 by 10 hoist, one guyed derrick and clam for use in loading from stock pile.

The limestone quarry in Prince Edward county owned by this company was not in operation during the year.

The officers of the company are: Alex. Longwell, president; George Rayner, manager, and S. Bradley, superintendent. Thirty men are employed at the Preneveau works.

Point Anne.—Point Anne Quarries, Limited, operating near the Canada Cement Company plant on the Bay of Quinte, ran steadily throughout the season of navigation. The quarry has been opened for a distance of three-quarters of a mile in length by 100 feet wide, with an average depth of 24 feet. An electric trolley line runs through the quarry from the loading dock to the siding on the Canadian Northern railway.

Drilling is done with a large Armstrong churn drill, which operates during the whole year and insures a constant supply of broken stone. Seymour electric power is used throughout the quarry and crushing plant, with the exception of the 60-ton Marion shovel, which is steam driven. The company ships rubble, crib-filling material, and all sizes of crushed stone.

The officers of the company are: M. J. Haney, president; J. H. M. Stewart, manager, and A. G. Bennett, superintendent. Forty men are employed during the season of navigation.

Pembroke.—Most of the crushed and building stone used in Pembroke and vicinity is supplied from the quarries owned by Wm. Markus, Limited, and Messrs. Kehoe Bros. Both are worked in a small way as the trade demands. They are situated on adjacent lots in the township of Pembroke about two miles east of the town. Rubble, crushed and building stone is supplied to the trade.

Renfrew Quarry.—The Jamieson Lime Company continued to operate their quarry near the town of Renfrew during the year. This company operate three quarries, one inside the town limits of Renfrew, and two in the second concession of Horton township, about two miles south of the town. Some years back a considerable quantity of stone from these quarries was shipped to the Sudbury smelters for fluxing purposes, but that trade gradually diminished as other sources were found nearer the works. When working to capacity the company produce 30 tons of white lime per day. J. A. Jamieson is manager.

Rideau Canal Supply Company.—In the township of Nepean, near the city limits of Ottawa, the Rideau Canal Supply Company operated their limestone quarry throughout the year. The working face is 20 feet deep over a distance of 300 feet; crushed stone supplied in five sizes, also rubble and building stone are delivered to the trade in Ottawa. Robert Foster is manager, employing 40 men.

H. Robillard and Son.—This quarry on lots 22 and 23 in the township of Gloucester, near the city of Ottawa, on the Montreal road, worked with reduced force

during 1915. One lime kiln was in commission, and only 10 men employed in the quarry on the date of inspection. Shipments include rubble, dressed and dimension stone and white lime, most of the product going to the trade in Ottawa. R. E. Robillard is manager.

Street and O'Brien.—On lot 7, concession II of the township of Leeds, near Gananoque, Messrs. Street and O'Brien quarry grey granite for use in making paving setts. No plant is required, and all the work is done by experienced stone cutters who are employed on a contract basis of a price per 1000 setts. Work is carried on during the summer months only. Fifteen men are employed.

Toronto Brick Company.—The quarry and lime kilns of this company at Coboconk, Victoria county, were closed most of the year. When running to capacity the company operate three kilns with a total output of 150 tons of lime per week. Charles Callan is superintendent, employing 15 men.

V.—SOUTHWESTERN ONTARIO

Quarries

Amherstburg Quarry.—This quarry, situated near the village of Amherstburg, and owned by the Solvay Process Company of Detroit, Michigan, was being pumped out in July, 1915, when the inspector visited the property. This quarry has been idle for several years. J. W. Foley is superintendent.

Beachville White Lime Company.—Near the village of Beachville, the company operate a limestone quarry for the manufacture of lime. The quarry and kilns, two in number, adjoin the property of the Standard White Lime Company. On account of the low magnesia content, this stone is desirable for fluxing in blast furnaces, and for use by chemical plants. Charles Downing is manager, employing fifteen men.

Brown Quarry.—This quarry has been described in previous reports as belonging to the Owen Sound Lime Works. It is now owned and operated by O. C. Brown, of Owen Sound. Operations were carried on and lime manufactured for about eight months in 1915, the demand for lime coming mostly from the farmers in the vicinity of Owen Sound.

Canada Crushed Stone Corporation.—The quarry operated by this company is situated on lots 12 to 16 inclusive, concession I of the township of West Flamborough, near the town of Dundas. The quarry is worked in two benches, the upper bench being 244 feet above the level of the Grand Trunk Railway, and the lower, 175 feet. The quarry proper is 1,000 feet long by 500 feet wide with a working face of 30 feet. This stone is shipped to the Hamilton steel plant for fluxing purposes. A second bench with a 25-foot working face is crushed for concrete and road material.

The stone is crushed in a No. 21 Power and Mining Company gyratory crusher. From the crusher it is conveyed to a set of rolls 72 inches by 30 inches, and from the rolls on a 30-inch belt conveyor to the revolving and shaking screens and properly sized for shipment.

An average sample of the stone shipped for fluxing purposes shows the following analysis:—

Silica	Iron Oxide	Alumina	$CaCo_3$	$MgCo_3$	Sulphur	Phosphorus
.41	.43	.59	55.20	43.60	.016	.005

An average sample of stone shipped for road material was tested at the Public Roads Department, Washington, D.C., with the following results:—

Specific gravity	2.80
Weight in pounds per cubic foot	175
Absorption per cubic foot	.24
Percentage of wear	3.6
Hardness	16
Toughness	11
French co-efficient of wear	11.1
Cement value	good

The company also have a contract with the Steel Company of Hamilton to take all their blast furnace slag, and this product is ground and sold to the trade for concrete purposes. Charles M. Doolittle is president and general manager of the company, employing eighty men.

Canada Cement Company—What is known as plant No. 8 of the above company is situated near Port Colborne, on lots 30 to 32 inclusive, township of Humberstone, Welland county. During 1915, the works were closed from February 13th to April 12th. The plant in the quarry and clay bank consists of two Marion 60-ton shovels, one Thew shovel used for stripping overburden, two Clipper churn drills, and one Browning hoist. S. R. Preston is local manager, employing twenty-five men in the quarry.

Canadian Quarries, Limited.—The quarry owned by this company was in operation during the year, with a force of thirty-five men. Crushed stone only is shipped from the quarry, which is located on lots 28 to 30 inclusive, concession V., township of Saltfleet.

The plant consists of one 35 h.p. horizontal boiler, one 25 h.p. portable boiler, one 40 h.p. horizontal boiler, one No. 6 and one No. 4 Austin gyratory crusher, and one six-section revolving screen, 24 feet long by 4 feet in diameter. D. D. O'Connor is president of the company and R. S. Stone, manager.

Coast and Lakes Contracting Corporation.—The quarry owned by this company in the township of Bertie, county of Lincoln, near Ridgeway, was in operation for three months only during the year, beginning September 1st, closing November 28th, and only large blocks of stone weighing from five to eight tons are shipped. The whole output for 1915 went to the Buffalo breakwater contract.

H. J. Eggleston of Cleveland, Ohio, is manager of the company, and M. E. Gloven, local superintendent, employing thirty-five men.

Chalmers Quarry.—Due to a decreased demand for white lime by the building trade in Owen Sound and vicinity, the above quarry and kilns operated for only eight months in the year. A force of four men was sufficient to supply the demand. The kiln has a capacity of 275 bushels per day, Stewart Chalmers succeeded his father as manager during the year.

Cook Quarry.—Near the town of Wiarton, Bruce county, on lots 7 and 8, in concession XXIV of Annabel township, J. S. Cook operates a small quarry for supplying dressed stone to the building trade. The plant consists of a small 5 h.p. gasoline engine and air compressor, drilling for plug and feather work being done by pneumatic tools. Five men are employed.

Empire Limestone Company.—The quarry operated by this company is one of the oldest in the Province. It is situated on lots 4 to 6, concession I., of Humberstone township, near Skerkston station, on the Grand Trunk line from Pt. Colborne to Buffalo. An area of 40 acres has been worked out, the average depth being 35 feet. During 1915, work in the quarry was practically abandoned, and sand from the shores of Lake Erie was shipped during the season of navigation. The demand for this product increased during the year both for domestic and United States shipments, and facilities were installed for all rail shipments. The company own four gas wells, with an average daily production of 82,800 cubic feet. M. B. Fuller is president of the company and John Haston manager. Fifty men are employed.

Fleming Quarry.—This quarry is owned by J. H. Fleming, of Toronto, and is situated on lot 26, concession IX, of Esquesing township, Halton county, adjoining the Logan quarry. During 1915 the output of the brown and blue sandstone produced at this quarry was greatly reduced owing to slack demand by the building trade. M. G. Bell, Glenwilliams, is manager of the quarry, and during the year a force of ten men was employed.

Gallagher Lime and Stone Company.—Near the Marshall quarry on lot 15, concession VI, of Barton township, the above company operate a small quarry for use in the manufacture of lime. The city of Hamilton affords a good market for the lime output, also for the rubble and building stone produced. Dan Gallagher, Hamilton, is manager of the company, employing ten men.

Gravenhurst Quarry.—The Gravenhurst Crushed Granite Company, Limited, worked a quarry in the town of Gravenhurst during part of the summer of 1915. The rock, which is a biotite granite gneiss, is sold only in the crushed form. The product is shipped by rail. The rock is trammed on the level and fed into a No. 8 Kennedy gyratory crusher. Thence it passes to two No. 6 Kennedy gyratorys and is carried by a bucket elevator to the upper floor of the building, where two rotary screens remove the undersize. The oversize is returned to a bin which feeds into

one of the No. 6 crushers, while the undersize, with the fines removed, is shipped. George H. Harper, Gravenhurst, is manager, and forty men were employed at the time of inspection.

Hagersville Crushed Stone Company.—The quarry owned by this company was opened in 1913 and operated at intervals since. During 1915 work was carried on for eight months. The quarry is situated about one mile east of the village of Hagersville on the line of the Michigan Central railway. The plant consists of one 60 h.p. locomotive type boiler, one No. 4 Austin crusher, one No. 5 Gates crusher, and a screening plant, with a capacity of 400 tons per day. Robert Hambleton is manager, employing thirty-five men.

Hagersville Contracting Company.—The quarry operated by this company is located on lot 14, concession XIII of Walpole township, near the village of Hagersville. Operations were carried on for eight months during 1915. The plant includes one 60 h.p. Fairbanks gas engine, one 150 h.p. St. Marys gas engine, one No. 7½ Gates crusher, two return tubular boilers of 100 h.p. each, two locomotive type-boilers, and one new 150 h.p. Jenckes boiler. The plant has a capacity of 1,000 tons of crushed stone per day, with shipping facilities on the Michigan Central, Grand Trunk and T. H. and B. railways. This quarry has been worked for many years and an area of 30 acres has now been worked out to a depth of 12 feet. John C. Ingles is manager of the company, and thirty-five men were employed during the year.

Harrison Quarry.—This quarry adjoins the Oliver-Rogers on the south and was opened by H. B. Harrison, of Owen Sound, during 1914. The stone is of particularly fine quality for building purposes, the whole output being shipped in rubble form for foundations. During 1915 the quarry operated for a short time only, and in November was closed entirely owing to the death of Mr. Harrison. The plant consists of one guyed derrick, one stiff-leg derrick, and one 15 h.p. upright boiler.

E. Harvey, Limited.—Messrs. E. Harvey, Limited, of Guelph, operated their limestone quarry near the village of Rockwood during the year.

The stone is well suited for the production of white lime, and the whole output of the quarry is burned in three large kilns, having a combined capacity of 40 tons of lime per day. Hydro-electric power is used to operate the quarry machinery and kiln fans. E. Harvey is manager, employing twenty-five men.

Hurst Quarry.—On lot 21, concession V of Esquesing township, Samuel H. Hurst, of Toronto, has reopened an old sandstone quarry which was first operated some sixty years ago. Work was commenced in one of the old openings, and on the date of inspection, in May, seven men were engaged in stripping the clay overburden at a point where the working face measured 15 feet in depth. The stone breaks easily, is of good, uniform color, and will be manufactured into sills, coursings, lintels and all kinds of building stone. A. Norton was in charge of the work for Mr. Hurst.

Logan Quarry.—This quarry, on lot 27, concession VIII of Esquesing township, operated at intervals during the year. For the first six months of the year building stone was in good demand, but during the latter half of the year the quarry was closed most of the time and only operated to fill small orders. The stone here is of excellent quality and a uniform grey color. The plant consists of one portable traction engine, three steam drills, and two guyed derricks. Rubble and building stoned is shipped, chiefly to the trade in Toronto. Hugh Logan, of Glenwilliams, is owner and manager.

Longford Quarry.—This quarry is situated near the village of Longford Mills, about seven miles south of Orillia, on lots 21 to 24 inclusive, township of Rama. The product is shipped mostly in the form of rough and dressed building stone. Up to 1913, when the furnaces of the Canada Iron Corporation at Midland closed down, stone from this quarry was used for fluxing purposes and found to be equal to any in Ontario for that purpose. The plant includes 13 guyed derricks, a small Rand compressor and one portable boiler. In 1915 the quarry was in operation from April 1st to December 31st. Fourteen men were employed, eight of these being stone cutters working piece work at a price per lineal foot. The officers of the Longford Quarry Company are:—President, Wm. Thompson; secretary-treasurer, Allen McPherson, and manager, C. C. Howlett.

Marshall Quarry.—On lot 14, in concession VII of Barton township, about three miles west of Hamilton, James Marshall operated his quarry for the production of lime during the summer months. Mr. Marshall is in charge of the work and operates two kilns, employing twenty-five men.

McCormick Quarry.—On the northwest corner of Pelee Island, at the old North Dock, is a limestone quarry which has been worked for rubble and building stone for many years. It is situated on subdivisions 17, 18 and 19, of lot 22 or lot 23, and is owned by John McCormick, Scudder, Ont. Very little work was done in this quarry in 1914 or 1915.

McKay and McPherson.—During 1915 Messrs. Alex. McKay, of Toronto, and Benjamin McPherson, of Owen Sound, opened a quarry for the production of rough building stone, on property lying adjacent to and south of Harrison's quarry, in Owen Sound. The working face is now 22 feet deep, and during 1915 four men were employed for eight months. About 1,800 tons of stone were shipped to the trade in Toronto.

Michigan Central Quarry.—Near the town of Hagersville, and adjoining the quarry of the Hagersville Contracting Company, the Michigan Central railway have opened up a large limestone quarry for supplying crushed stone for surfacing material, rubble for pier filling and in addition some dimension stone for buildings. The quarry was idle throughout 1915, but began operations in January, 1916, with seventy men. D. E. Cronin is manager for the railway company.

Oliver-Rogers Quarry.—The crushed and rubble stone business in Owen Sound fell off considerably during 1915, the output showing a decided decrease. The above quarry is the largest in Owen Sound and enjoyed a steadily increasing business up to 1915. During the year operations were carried on for nine months with a force of fifteen men. The plant includes three guyed derricks, one stiff-leg derrick, one Thew steam shovel, one No. 4 McCully crusher, screening plant and storage bins. The normal output is about 250 cars of crushed stone monthly, in addition to large shipments of rubble. S. J. Oliver is president and manager of the company.

Queenston Quarry Company.—This quarry, one of the largest in the Province, is situated on lots 47 to 49, in concessions II and III of Niagara township. The stone at this quarry is particularly well suited for building purposes, and consequently a large portion of the business is in dimension stone. Crushed stone for concrete work and road material, also rubble for cellars and pier filling, is shipped. The plant was enlarged during the year, and two large gang saws, one diamond saw and planer added. These will be utilized in getting out large dimension orders for building contracts. The boiler, compressor, and crushing plants remain the same. As noted in previous reports of the Bureau of Mines, Charles Lowery is president and manager of the company, employing during the year an average of seventy-five men.

F. Rogers and Company.—On the east half of lot 30, in concession VI, and the east half of lot 31, in concession V of Chinguacousy township, Messrs. F. Rogers and Company, of Toronto, are operating quarries in the Credit Valley sandstones. The plant consists of one Abel traction engine, one D. D. Robertson hoist, one 16 h.p. upright boiler and one guyed derrick with 54-foot boom. The product is shipped in the form of building stone and rubble, and is hauled to the Grand Trunk railway siding at Terra Cotta. R. M. McIntyre is superintendent, employing thirty men.

Standard Crushed Stone Company.—This company, with head office at Niagara Falls, operated two quarries during 1915. The St. David quarry is located on lot 44, in Niagara township, a short distance from the Queenston quarry. The plant at this quarry includes one Bury compressor, two dinky locomotives, one No. 5 Gates crusher, revolving screens and storage bins.

In the township of Bertie, near the village of Ridgeway, the company continued to operate the quarry opened in 1914. The pit at the close of 1915 had the following dimensions: Length 250 feet, width 125 feet, average depth 26 feet. The plant here is electrically driven with power from the Canadian and Niagara Power Company. Crushed stone in all sizes is shipped. The officers of the company are:—John Symmes, president; Robin Boyle, secretary, and J. H. Barbeau superintendent. Each quarry employs thirty-five men.

Standard White Lime Company.—This company operated quarries for the production of lime at Guelph, Beachville and St. Marys. The plant in the city limits of Guelph was closed during the year. In the township of Puslinch, a short distance

west of the city limits of Guelph, the company operated a large quarry with three kilns, having a combined capacity of 20 tons of lime per day. At this quarry also is situated the largest plant manufacturing hydrated white lime in the Province. At Beachville, near Ingersoll, there are five kilns with a capacity of 50 tons of white lime per day. The St. Marys quarry worked during the summer of 1915. Twenty feet of limestone is used, but, as the clay overburden is becoming deeper, being from 8 to 18 feet in depth, costs are increasing. Black powder is used for blasting. Eleven men are employed. D. D. Christie is president of the company and J. Kennedy manager, with head office in Guelph.

St. Marys Portland Cement Company.—The quarry and plant of this company are situated in the town limits of St. Marys, and operations were carried on continuously during the year, the output being considerably increased. The quarry proper is now 400 feet long by 350 feet wide and has an average depth of 30 feet. The stone is broken in a No. 8 Kennedy crusher, capacity 150 tons per hour, and conveyed to the cement plant by a belt conveyor, 400 feet in length. A churn drill will be installed at once to replace the two No. 43 Rands at present in use. Every care is taken to prevent accidents at this quarry, and the rule of "Safety First" is everywhere observed. About forty-five men are employed in the quarry.

Clay, for mixing with the crushed limestone, is found in close proximity to the quarry, and in places forms the overburden. At the close of the year the clay excavation measured 400 feet long by 250 feet wide, with an average depth of 25 feet.

The officers of the company are:—Geo. H. Gooderham, president; Mark Irish, secretary, and J. G. Lind, manager.

St. Marys Horse Shoe Quarry.—This quarry is located in the town of St. Marys, near the cement plant, and during 1915 was in operation from April 1st to December 15th, and 25 men were employed. Crushed stone and rubble for pier filling was shipped. R. H. McWilliams, of St. Marys, is manager for the St. Marys Horse Shoe Quarry, Limited.

Thames Quarry Company.—This quarry, in the town of St. Marys, is a steady producer of crushed stone, rubble and dressed stone for coursings. A small plant for the manufacture of lime brick is also in operation, and utilizes the fines from the quarry operations. During the year a new crusher building was erected in the south end of the quarry, doing away with the long haul to the former plant. The quarry was in operation from April 1st to December 15th and thirty-five men were employed. David Bonis is manager of the company.

Toronto Lime Company.—This company operates quarries for the manufacture of white lime, at Dolly Varden, in concession III of Esquesing township, and at Limehouse, in the same township. When running to capacity the combined kilns produce 45 tons of lime per day. The Limehouse quarry and plant closed in March, 1915, and for the balance of the year the Dolly Varden plant supplied the demand. Wm. Gowdy is superintendent, employing twenty men.

Wentworth Quarry Company.—The limestone quarry operated by this company is situated on lot 4, concession V of Saltfleet township, near Vinemount Station, T.H. & B. Railway. Crushed stone of the usual sizes is shipped to the trade throughout the Province, and during 1915 the output was slightly increased in spite of the prevailing depression in the building trade. A second Marion shovel has been added to the plant, giving increased loading capacity. The crushing plant includes one No. 7½ McCully crusher, one No. 5 McCully crusher, one 6-section revolving screen, 20 feet in length by 4 feet in diameter. The plant is driven by a Duddbridge, twin-cylinder gas engine, supplied by a 115 h.p. gas producer plant. F. W. Schwendiman is manager, employing twenty-five men.

Gypsum

Caledonia Mine.—The Alabastine Company, Limited, are the largest producers of gypsum products in the Province. The chief producing mine and large plaster mills are located near the village of Caledonia, on lots 10 and 11, in the township of Seneca, range I, west of the Hamilton road. The deposits of gypsum along the valley of the Grand river have been worked for many years and described in successive annual reports of the Bureau. During the year the mine worked continuously with a reduced force of 20 men. The three-foot seam on the 3rd level has been further developed by the pillar and room method.

The following gypsum products are manufactured at the Caledonia mine:—Paristone wall plaster, pulpstone wall plaster, fireproof blocks, and land plaster. The head office of the company is at Paris, and the officers are as follows:—M. B. Church, president; R. E. Haire, general manager, and A. J. Parkhurst, superintendent.

Carson Mine.—This mine is owned by the Alabastine Company, and is situated about three miles south of Caledonia, in Oneida township.

During 1915 it was worked for four months with a force of four men, and the output teamed to the mill at Caledonia. The gypsum here is of the pure white variety and is used for manufacturing finishing plaster, resembling Keene's cement when finely ground. The bed is only four feet in thickness, overlaid by four to six feet of dolomitic shales and limestones. On account of the bad roof great care has to be taken in mining to protect the men. The mine is under the management of Mr. Parkhurst.

Crown Gypsum Company.—The mine from which this company secures its supply of gypsum is situated on the Martindale farm, lots 58 and 59, township of Oneida. It is reached by good wagon road from Caledonia to the village of York. The gypsum is of the pure white variety, occurring in a four-foot bed. The product is hauled from the mine to the grinding plant and plaster mill at Lythmore on the company's narrow gauge railway.

C. E. Williams is manager of the company and G. C. Fischle, mine superintendent, employing thirty men at the mine.

VI.—ONTARIO IN GENERAL

Blast Furnaces

Algoma Steel Corporation.—Two of the blast furnaces at Steelton, Ont., were operated during 1915. These two furnaces produce about 575 tons of pig iron per day and suffice to keep the open hearth plant running. The ores used are approximately thirty per cent. Helen and Magpie ores combined, thirty-five per cent. Old Range ores and thirty-five per cent. Mesabi ores.

A duplex plant is being added and will be in operation early in 1916. When this is completed the No. 3 or 500-ton blast furnace will be blown in. By means of the duplex process the basic pig from the blast furnace is blown in a Bessemer converter to remove the greater part of the carbon and silicon. The metal is then taken to a Talbot tilting open-hearth furnace where it is charged in the molten condition and finished. By thus using the Bessemer converter in conjunction with the open-hearth furnace the time required to bring the pig metal to steel is materially reduced, because the Bessemer converter removes both carbon and silicon at a much faster rate than the open-hearth furnace can if used alone.

The merchant mill has been working since the summer of 1915.

At the time of last inspection of the blast furnaces (December, 1915), 2,255 men were employed at the steel plant.

The officers are: President and general manager, J. Frater Taylor; vice-president, W. C. Franz; assistant to general manager, C. J. Wilson; general superintendent, Lawrence Cooney; superintendent of blast furnaces, James H. Bell.

The Greenawalt experimental roasting plant at Sault Ste. Marie, Ont., was idle during the greater part of 1915. The crushing plant in connection with the same worked from September 1st to October 15th, crushing dolomite from Michigan to pass ½-inch ring. This crushed dolomite was calcined at the Magpie mine roasting plant and used for lining the basic open-hearth reverberatories at the steel-plant in place of the Austrian grain magnesite. From October 15th to the end of the year, the experiments on the roasting of the Magpie ore by the Greenawalt process were continued. The plant is also used for sintering blast furnace flue dust. When iron ore is being treated a Symons disc crusher first reduces it to about ¾-inch. It is then passed through a trommel and the oversize reduced by a pair of superior rolls. All is then taken by a bucket elevator to a bin. It is then charged into a concrete mixer and coke and water added. A bucket elevator delivers the mixture to a charging car. J. M. Knote is superintendent.

Canadian Furnace Company.—The blast furnace of this Company at Port Colborne was in continuous blast from March 10th, 1915, to the close of the year, with the exception of a fortnight shut down in November, for relining.

An average production of 360 tons of pig daily was maintained throughout the operating period. The ore charged was all imported, the 2,800 tons of magnetite from the Ledyard mine in Hastings county, being still in stock. The limestone used came from the quarries at Calcite, Michigan. The advantages in using this

imported limestone in preference to the local product, are uniformity of size, facilities for unloading and placing on stock pile, and low price f.o.b. Port Colborne.

During the year the Company purchased a pulmotor for use at the Port Colborne plant, and installed many safety appliances for the protection of the 130 men employed. B. Marron is president and general manager, and D. J. Higgins, superintendent.

Standard Iron Company.—The blast furnace of the Standard Iron Company began operations April 9th, 1915, and continued to the close of the year. An average daily production of 60 tons of high grade charcoal pig was produced. Foreign ores were charged exclusively, although experiments were made with local magnetites. The furnace at Parry Sound, owned by this company, was not in blast during the year, but operations will likely be resumed at this plant early in 1916.

G. L. Shook is manager of the company, employing 80 men.

Steel Company of Canada.—This Company operate two blast furnaces at their plant in Hamilton, and during 1915, the large furnace "B," ran to capacity throughout the year. This furnace has a capacity of 325 tons of pig iron per day. The smaller furnace "A" was not in continuous blast.

Early in 1916, what is known as the Metal Trades Safety Association was formed, and a set of safety rules drawn up. These will be presented to the Workmens' Compensation Board for their sanction and approval, with the object of enforcing a uniform set of safety regulations for all branches of the metal trade.

Robert Hobson is vice-president of the company and R. G. Wells, works manager.

Refineries

Canadian Smelting and Refining Company—As stated in the Twenty-Fourth Annual Report of the Bureau of Mines, this company was formed in October, 1914, and took over the assets of the Canada Refining and Smelting Company at Orillia. During the early months of 1915, the company continued to treat Cobalt ores and residues from the high-grade mills. In May, 1915, the company went into liquidation, and the plant was taken over by the Orillia Molybdenum Company, the whole attention of the management for the balance of the year being directed to processes for treating molybdenite ores.

Coniagas Reduction Company, Limited.—The head office of this company is at St. Catharines, with works near Thorold, in Welland County. This plant was the third in Ontario erected to treat Cobalt ores, and the first shipment was smelted in May, 1908. Since that date the plant has operated continuously. When first erected, the output consisted of refined silver and the oxides of cobalt and nickel, but other products were manufactured as new methods were worked out in the metallurgy of cobalt ores. At present, silver, arsenic, cobalt oxide and metal, and nickel oxide, are refined and shipped. The company has treated all the ore produced

by the Coniagas mine and has been a large purchaser of custom ores and mill products.

The system of sampling varies somewhat from that at Deloro. The ore is first ground in a Krupp mill, and passed through a double Vizen sampler, which takes two independent samples from the pulp. These are subdivided, and constitute the basis of the final sample of about twenty pounds, on which the purchase is completed. The treatment process may be roughly described as follows:

The crushed ore is mixed with the required flux and smelted in a blast furnace, producing silver bottoms, speiss, slag, and arsenical fume. The speiss is first crushed and roasted, then sent to the cobalt plant where the cobalt and nickel are extracted. The silver bearing residues are returned to the furnace department. The silver bottoms are treated in a reverberatory furnace, then cast into anodes and refined electrolytically. The arsenical fume is collected in the bag house, and then treated in refining furnaces, which by a volatilization process yield refined white arsenic and non-volatile product which is returned to the smelting department.

The officers of the company are: R. W. Leonard, president and general manager; R. L. Peek, superintendent of works and J. J. Mackan, secretary.

*Deloro Mining and Reduction Company**.—This company has its head office and works at Deloro, Hastings County, and its plant was the second in the Province, erected to treat cobalt ores. The first car of ore was smelted in December, 1907, and operations have been carried on continuously since that date, each year showing an increased production. When first erected the product was confined to silver, refined arsenic and cobalt oxide, but the plant has been gradually extended and at present the company refine and ship silver, cobalt oxide and metal, nickel oxide and metal, and arsenic. There is also a plant for the manufacture of stellite, a high grade tool steel. In the metal department, experiments are being conducted in electro-plating with cobalt, and investigations made in an endeavour to find other uses of that metal.

Ores and mill products from the Cobalt district are purchased on a basis of silver content. Sampling is done very carefully under the supervision of a representative of the seller, and the process in use is as follows: Each car-load is stored in a separate bin and the lump ore crushed to 15 mesh in a ball mill, to which is attached a Snyder sampler. This machine takes about 50 samples per minute, each one representing about ten per cent. of the volume of crushed material leaving the mill. The total sample thus obtained is subdivided until a final sample of about 20 pounds, representing the whole car-lot, is obtained. The coarse scales of silver which did not pass the ball mill screens are melted, and the bar thus obtained is added to the assay of the sample taken as above, and this represents the total value of the parcel purchased.

The following are typical assays, of ores and mill products received at the smelter:

* The company was reorganized in 1916, and is now known as The Deloro Smelting and Refining Company, Limited.

	Fine Ounces per ton	Percentages.								
		Co	Ni	Cu	Fe	As	S	SiO_2	CaO_2	MgO
Ore (hand-picked).	2,194	7.9	4.3	0.1	5.0	30.2	1.7	4.17	15.0	2.7
Ore Jig product...	1,442	10.4	5.8	0.2	6.5	47.2	3.7	4.5	5.2	0.8
Ore Table Concentrate.....	1,426	8.2	3.8	0.25	11.6	37.1	8.25	9.5	.....	.....
Ore Slime.....	324	2.1	.5	.....	6.8	10.0	2.98	58.3	2.5	1.92

The treatment process may be roughly outlined as follows: The crushed ore, with the required fluxes, is mixed in a pug-mill and smelted in a low pressure blast furnace, producing slag, speiss, and crude silver bottoms. The speiss is re-crushed, calcined in coal-fired reverberatory furnaces or in oil-fired Bruckner furnaces, and the calcined product conveyed to the chloridizing furnaces where it is roasted with salt.

The calcined speiss after the above treatment goes to agitating tanks, and the silver extracted by sodium cyanide. Metallic silver is precipitated from the cyanide solution by the addition of aluminum dust. This is known as the Kirkpatrick process, being the invention of Prof. S. F. Kirkpatrick, School of Mining, Kingston. The silver obtained is exceptionally high grade, and the cyanide is to a large extent regenerated.

The residues pass to the cobalt and nickel department, and the crude arsenic oxide recovered in flues and bag-houses. The crude silver bottoms are heated in an oxidizing atmosphere in oil-fired, cylindrical, rotary furnaces, and the impurities removed. The silver thus obtained is mixed with the silver precipitate from the cyanide process, and given further treatment with borax and nitre in an oil-fired tilting furnace, from which it is poured into moulds for the market.

The residues from the cyanide treatment are given further treatment for the separation by precipitation of cobalt and nickel.

The works has a capacity of 400 to 500 tons per month and is producing monthly about 50,000 to 60,000 pounds of cobalt oxide and metal; 15,000 to 20,000 pounds of nickel oxide and metal and 500,000 ounces of silver.

The officers of the company are:—M. J. O'Brien, president; Thos. Southworth, vice-president and managing director; S. B. Wright, general manager; S. F. Kirkpatrick, consulting metallurgist and F. A. Bapty, secretary-treasurer.

Electro Zinc Company, Limited.—This company began operations in November, 1915, at Welland. The plant at present has a maximum capacity of 30,000 lbs. of refined zinc per month. Roasted zinc concentrate is used in this production. A specimen analysis of the product is as follows:—

Zinc	Iron	Lead	Tin	Cadmium	Total
99.98	0.01	0.01	nil	nil	100.00

The Watts process is used, an electrolytic process wherein the same tanks serve for leaching and electrolysis. The process and the apparatus were invented by Ernest E. Watts.

The officers of the company are:—President, Weston Lewis; 1st vice-president, L. D. Adams; 2nd vice-president, C. H. Maxcy; treasurer, J. H. Maxcy; secretary, J. P. Wells and manager, E. E. Watts. The secretary's office is Sherbrooke, Que., and that of the treasurer, Gardiner, Maine, U.S.A.

Metals Chemical, Limited.—This company was organized in February, 1915, under Dominion charter, for the purpose of treating low-grade Cobalt ores and residues.

The plant of the Metals Chemical Company, Limited, situated at Welland, Ontario, was purchased and various extensions and alterations made for treating ores, using processes evolved by C. Gordon Richardson. The plant includes two horizontal tubular boilers, 150 h.p., filter presses, mixing and settling tanks, crystallization tanks, and one new blast furnace, with a capacity of 30 tons of ore per day. The speiss from the blast furnace is crushed in a Sturtevant jaw crusher, then through a set of Sturtevant rolls and Hardinge ball mill to the roasting department.

The blast furnace stack is connected with a concrete return flue 600 feet in length, by 6.5 feet by 4 feet inside dimensions, which collects most of the arsenical fumes, the remainder from the blast furnace and roasting furnace going to the bag house. The blast furnace slag is very low in metallic contents and is rejected. The roasted speiss is re-ground and given further treatment.

The following products are shipped: Cobalt oxide, cobalt carbonate, cobalt sulphate, nickel oxide and sulphate, refined silver and arsenic.

C. G. Richardson, Welland, is president of the company and J. H. Charles, secretary. An average of 60 men are employed.

Sand and Gravel

Washing Plants.—There are now three plants for washing sand and gravel in the Province. These are operated by The Armstrong Supply Co., Limited, at Hamilton; Hamilton Sand and Gravel, Limited, at Hamilton; Windsor Sand and Gravel Co., Limited, near Leamington.

The Armstrong Supply Company, Limited.—On March 13th, 1915, the Armstrong Supply Company, Limited, put in operation a gravel washing plant at their gravel pit on York Street, Hamilton, Ont. The plant was built by the Cable Excavator Co., of Philadelphia, Pa., and is guaranteed to produce 500 tons of prepared material in ten hours. Storage capacity is provided for 600 cubic yards.

The sand and gravel is dug by a cable drag excavator, made by the American Road Machine Co., of Goderich. This excavator is operated by a Fleury Mfg. Co. hoist, driven by a 75-h.p. motor and mounted on a turntable at the top of the washing plant building, which is 100 feet high. The sand is dumped into a hopper in the upper part of the building and then passed over a grizzly. The oversize goes to a No. 5 Champion jaw crusher. The undersize and also the crushed material

pass to a set of three shaker screens upon which water is fed through a perforated 5-inch pipe. The oversize from the top screen, which is 15 feet long and has 1½-inch round perforations, is delivered to a No. 4 Champion crusher and is then elevated by a 30-foot bucket elevator and rewashed. The oversize from the two lower screens is collected in storage bins. The undersize from the screens passes into a settling tank equipped with a travelling scraper. The sand is discharged at one end of the tank and the mud and water over the other. Water is supplied by a No. 5 Smart-Turner centrifugal pump with a capacity of 370 U.S. gallons per minute.

Hydro-Electric power is used and is transformed from 2,200 to 550 volts. The pump is driven by a 30-h.p. motor; the hoist by a 75-h.p. and the crushers, screens, scraper and elevator by a 75-h.p.

Five men were employed at the time of inspection (September 28th, 1915), in the washing plant and pit.

The officers of the company are: President, Chas. Armstrong; secretary-treasurer, C. K. Armstrong; and manager, Z. M. Armstrong. The office is at 1050 Cannon Street East, Hamilton, Ont.

Hamilton Sand and Gravel, Limited.—So far as is known this company constructed the first gravel washing plant in the Province of Ontario. This plant is at Junction Cut, Burlington Heights, York Street, Hamilton, Ontario, and was first operated April 7th, 1915. It has a rated capacity of 300 cubic yards of gravel per day of ten hours.

The excavating is done by means of a one-yard drag-line bucket. This is hoisted by a Wettlaufer double-drum hoist and dumped into a chute. A grizzly removes part of the sand, by passing it to a bucket elevator. The remainder passes through a No. 5 Mitchell jaw crusher. The material discharged from the crusher is taken by the bucket elevator to a small galvanized iron box out of which it is washed by jets of water. Then it passes to stationary wire screens. The water and material passing through the first screen are collected in a wooden settling box fitted with five spouts near the bottom. The water does not play on the lower coarser screen. The muddy water overflows from the settling tank and a float discharges the sand through the spouts at intervals. Two of the spouts yield coarse sand, one medium and two fine. The water is supplied by a Smart-Turner centrifugal pump rated at 400 U.S. gallons per minute against a head of 218 feet.

The plant is driven by Hydro-Electric power. A 75-h.p. motor drives the hoist and a 40-h.p. motor the crusher and bucket elevator. Four men were employed at time of inspection.

The officers of the company are: President, Fred. Yapp, Hamilton; manager and secretary, Wm. Kerr, 806 Bank of Hamilton Building, Hamilton, Ont.

Windsor Sand and Gravel Company, Limited.—The Windsor Sand and Gravel Company, Limited, operate a gravel pit and washing plant in Lots 1 and 2, Con. 2, Mersea Township, about two miles west of the town of Leamington.

The gravel is loaded into a two-yard Stephens-Adamson steel skip by a Browning Engineering Co. crane. The skip is hauled up a timber incline and emptied into a hopper. This hopper is discharged by means of a reciprocating feeder into

a revolving screen 42 inches diameter by 16 feet long. The upper ten feet of this screen has one-inch perforations; the lower six feet has two-inch perforations. Water is fed into this screen through a 2½-inch pipe. The oversize from No. 1 screen passes to a No. 3D Gates gyratory crusher which reduces it to 1½ inches. The crushed rock is carried back to the above-mentioned hopper by means of a bucket elevator. The undersize from the No. 1 screen is fed into No. 2 screen, a 72-inch Gilbert conical with ⅜-inch round perforations. The undersize from the No. 2 screen is delivered to two 72-inch Gilbert conical screens with ⅛-inch by ½-inch slot perforations. The undersize from screens 3 and 4 passes into an automatic settling tank equipped with a counterweight which causes the sand to be discharged at intervals. The muddy water and very fine sand overflows from the settler into a tank divided into two compartments which are used alternately. The 1-inch to 2-inch material from screen No. 1 and the oversize from the three conical screens passes directly into storage bins.

The machinery is operated by electric power supplied by the Essex County Light and Power Company, Leamington, and transformed to 220 volts. The crusher is driven by a 15-h.p. motor; the screens by a 35-h.p. motor, and the bucket elevator temporarily by a 35-h.p. motor. Water is supplied by a 5-inch Mather and Platt centrifugal pump capable of delivering 400 gallons per minute against a head of 85 feet. The plant is said to have a capacity of 400 cubic yards of washed gravel per day, and was put in operation in July, 1915.

The head office of the company is at Walkerville and the officials are: President, Wm. Woollatt, Walkerville, Ont.; manager, J. E. Laughlin, Walkerville, Ont.

Inspection of Excavations.—The excavations of the following sand and gravel operators were inspected during the year. In addition to the 249 inspections noted below, there were 162 inspections of clay and shale excavations made during the year. A fairly complete list of the important brick and tile manufacturers is given in the statistical part of this Report, and for this reason is not repeated here.

EASTERN ONTARIO AND NIAGARA PENINSULA.

Name.	Material.	Address.
Armstrong Supply Company	Gravel	Hamilton.
Allen Bros.	Gravel	Toronto.
Armstrong, John J.	Sand and Gravel	Iroquois.
Annable, Albert	Gravel	Moulinette.
Aube, Ephraim	Gravel	Berwick.
Arnold, Thomas	Gravel	Lindsay.
Aldworth, John	Gravel	Bowmanville.
Arnott, James	Gravel	Georgetown.
Ackroyd, Robert	Gravel	Stanley Mills.
Bartonville Gravel Pit	Gravel	Hamilton.
Burns, Dean	Gravel	Pembroke.
Blair, James	Gravel	Arnprior.
Brouse, James	Gravel	Iroquois.
Becksted, Albert	Gravel	Morrisburg.
Bowles, William	Gravel	Newington.
Bazinet, Joseph	Gravel	Chrysler.
Brisson, Charles	Gravel	Brisson.
Baltimore and Cobourg Gravel Road Co.	Gravel	Baltimore.

EASTERN ONTARIO AND NIAGARA PENINSULA.—*Con.*

Name.	Material.	Address.
Brown, W. B., and Sons	Gravel	Peterboro'.
Bonnell, T. W.	Sand	Whitby.
Broughton, W. A.	Sand	Whitby.
Beaument, Joseph	Sand	Glen Williams.
Buck, James	Gravel	Georgetown.
Bovaird, James	Gravel	Brampton.
Clifton Sand and Gravel Corporation	Sand and Gravel	Stamford.
Clarke, Richard	Gravel	Smiths Falls.
Colquhoun, George	Gravel	Williamsburg.
Casselman, Emma	Gravel	Williamsburg.
Cleary, Thomas	Gravel	Mille Roches.
Casselman, Alfred	Gravel	Berwick.
Creeper, John	Sand and Gravel	Belleville.
Curtis, Edward	Gravel	Peterboro'.
Croft, Robert	Gravel	Peterboro'.
Curtis, Walter	Gravel	Lindsay.
Corley, Richard	Gravel	Lindsay.
Collacutt, Robert	Gravel	Bowmanville.
Conlin, Fred.	Gravel	Oshawa.
Clifford, Burton	Sand	Oshawa.
Crawford, Bert	Gravel	Brampton.
Crawford, John	Sand and Gravel	Brampton.
Chesney, W. J.	Gravel	Huttonville.
Campbell, D. K.	Gravel	Dunvegan.
Corporation, Town of Lindsay	Gravel	Lindsay.
Corporation, City of Peterboro'	Gravel	Peterboro'.
Corporation, City of Oshawa	Gravel	Oshawa.
Corporation, Town of Prescott	Gravel	Prescott.
Doyle, William	Gravel	Caledonia.
Doyle, Michael	Gravel	Caledonia.
Daniels, William	Gravel	Domville.
Day, Alexander	Gravel	Mille Roches.
Durivage, A. F.	Sand	Casselman.
Davis, M. J.	Sand	Brampton.
Empey, Guy	Gravel	Finch.
Foster, F. W.	Sand	Caledonia.
Forgues, Dieudonne	Gravel	Casselman.
Griffith, Johnson	Gravel	Pembroke.
Gillespie, John	Sand	Perth.
Gowland, Isaac	Gravel	Caledonia.
Gillard, David	Gravel	Williamsburg.
Garlough, Jacob	Gravel	Williamsburg.
Godard, Michael	Gravel	Crysler.
Gauthier, Nap.	Sand	Alexandria.
Gibson, James	Sand	Belleville.
Graham, James	Gravel	Canton.
Garvey, Timothy	Gravel	Peterboro'.
Griffin, J. A.	Gravel	Georgetown.
Hamilton Sand and Gravel Company	Sand and Gravel	Hamilton.
Healey, Frank	Gravel	Smiths Falls.
Hamilton, Robert	Gravel	Caledonia.
Hume, R. Wesley	Gravel	Northfield.
Honey, Stephen	Gravel	Bowmanville.
Hyland, George	Gravel	Oshawa.
Harlock, Joseph	Gravel	Whitby.
Jackson, F.	Gravel	East Toronto.
Johnson, H. L.	Sand	North Toronto.
Jack, Daniel	Gravel	Oshawa.
Kingston Sand and Gravel Company	Sand and Gravel	Kingston.
Keefer, C. H.	Sand and Gravel	Ottawa.
Kerfoot, George	Sand and Gravel	Smiths Falls.
Kennedy, Duncan	Gravel	Maxville.
Lecuier, Louis	Gravel	Bowesville.

EASTERN ONTARIO AND NIAGARA PENINSULA.—*Con.*

Name.	Material.	Address.
Larioiere, Alex.	Sand	Alexandria.
Laidlaw, Matthew	Gravel	Norval.
Laird, Alfred	Gravel	Norval.
Maher, William	Gravel	Western Road.
Maple Sand and Gravel Company	Sand and Gravel	Maple.
Morrison, Jos. H.	Sand and Gravel	Brockville.
Markus, William	Sand and Gravel	Pembroke.
Moore, George	Gravel	Caledonia.
Merkeley, Charles	Gravel	Williamsburg.
Mattice, Herbert	Sand	Wales.
Murphy, William	Gravel	Wales.
Montgomery, Chapman	Gravel	Moose Creek.
Magladery, Thomas	Gravel	Leonard.
Mitchell, Thomas	Gravel	Peterboro'.
Murphy, Patrick	Gravel	Lindsay.
Montgomery, John	Gravel	Bowmanville.
Malleable Iron Works Company	Sand	Oshawa.
Miller, Robert	Sand	Norval.
Metcalfe, William	Gravel	Greenfield.
Municipality, Township of Cumberland	Gravel	Cumberland.
Municipality, Township of Hamilton	Gravel	Cobourg.
Municipality, Township of Hope	Gravel	Welcome.
Municipality, Township of Ops	Gravel	Lindsay.
Municipality, Township of East Whitby	Gravel	Columbus.
McKay, Charles	Gravel	Toronto.
McLean, David	Sand and Gravel	Perth.
McMillan, Arthur	Gravel	Chesterville.
McGillis, Hugh	Gravel	Harrison.
McMillan, Ronald	Gravel	Finch.
McKinnon, Angus	Gravel	Alexandria.
McPhee, D. A.	Gravel	Vankleek Hill.
McGuire, Patrick	Gravel	Lindsay.
McIntosh, Hugh	Gravel	Dunvegan.
McLeod, Norman R.	Gravel	Dunvegan.
McDonald, A. K.	Gravel	Greenfield.
McDonald, D. A.	Gravel	North Lancaster.
New, Edward	Gravel	Hamilton.
Norton, John	Gravel	Newtonville.
Nichols, H.	Gravel	Richmond Hill.
Nesbitt, Robert A.	Sand and Gravel	Ottawa.
Nicholas, Gideon	Sand	Caledonia.
Ollman Bros.	Gravel	Hamilton.
Ontario Sand Company	Sand	Niagara Falls.
O'Connell, J. T.	Sand	Peterboro'.
Prosser, Edward	Gravel	Toronto.
Pringle, Frank	Gravel	Toronto.
Porter, Thompson	Sand and Gravel	Toronto.
Patterson, Thomas	Gravel	Arnprior.
Pascoe, Oliver	Gravel	Whitby.
Quinn, John S.	Gravel	Peterboro'.
Reinville, Adolphe	Sand and Gravel	Casselman.
Rice, John	Gravel	Whitby.
Robinson, William	Gravel	Prescott.
Robinson, Alfred	Sand and Gravel	Lindsay.
Robinson, Richard	Gravel	Lindsay.
Robinson, Albert	Gravel	Oshawa.
Rudd, John	Gravel	Huttonville.
Rumble, Harry	Gravel	Maple.
Sherwood, Geo. E.	Sand and Gravel	Brockville.
Shanks, James	Gravel	Smiths Falls.
Smith, Arthur	Sand	Caledonia.
Sterritt, David	Gravel	Prescott.
Smith, John	Sand	Prescott.

EASTERN ONTARIO AND NIAGARA PENINSULA.—*Con.*

Name.	Material.	Address.
Styles, Geo.	Sand	Morrisburg.
Shanette, Alexander	Gravel	Williamsburg.
Sleeman, Philip	Gravel	Welcome.
Snowden, Thomas	Gravel	Bowmanville.
Sully, W. J.	Gravel	Hampton.
St. David Sand Company	Sand	St. David.
Stamford Sand Company	Sand	Stamford.
Scott, Harold G.	Sand and Gravel	Niagara Falls.
Taylor, Frank	Gravel	Madoc.
Thompson, Albert	Gravel	Port Hope.
Thomas, William	Gravel	Oshawa.
Union Stock Yards	Sand and Gravel	West Toronto.
Webb, William	Gravel	Hamilton.
Watson, John	Sand and Gravel	Maple.
Whittaker, H. M.	Gravel	Williamsburg.
Weaver, Thomas	Gravel	Williamsburg.
Winters, Howard	Gravel	Mille Roches.
Woods, Cory	Gravel	Moulinette.
Winter, James	Gravel	Newington.
Walsh, W. J.	Gravel	Bearbrook.
Walker, Hiram	Gravel	Port Hope.
Weese, William	Gravel	Lindsay.
Willoughby, J. A.	Gravel	Georgetown.
York Sand and Gravel Company	Sand and Gravel	East Toronto.
Yates Gravel Pit	Gravel	Hamilton.
Young, David	Gravel	Caledonia.

SOUTHWESTERN ONTARIO

Name.	Material.	Address.
Armitage, Michael	Gravel	Lucan.
Aitcheson, Thos. W.	Gravel	R.R. No. 3, Stratford.
Baskerville, Henry	Gravel	R.R. No. 4, Thorndale.
Bott, Raywood	Gravel	R.R. No. 4, Thorndale.
Bassow, William M.	Gravel	R.R. No. 3, Zurich.
Collins, John	Sand	Putnam.
Conn, Malcolm	Gravel	R.R. No. 4, St. Marys.
Cann, John	Gravel	R.R. No. 3, Exeter.
Carroll, Robt.	Gravel	Watford.
Clendenning, James	Gravel	Copleston.
Cann, John W.	Gravel	Copleston.
Copling, Peter	Gravel	R.R. No. 2, Zurich.
Dowding, Albert	Gravel	R.R. No. 1, Kerwood.
Durr, Lewis H.	Gravel	R.R. No. 8, Parkhill.
Eckstein, John	Gravel	R.R. No. 2, Zurich.
Erb, Christian	Gravel	R.R. No. 2, Zurich.
Erb, John G.	Gravel	R.R. No. 2, Zurich.
Erb, Dilman K.	Gravel	R.R. No. 3, Stratford.
Finnegan, Chas.	Gravel	R.R. No. 5, Stratford.
Frazer, Wilmot	Gravel	R.R. No. 5, Stratford.
Fewster, Robt.	Gravel	R.R. No. 4, St. Marys.
Fleming, Robt.	Gravel	R.R. No. 5, Watford.
Francis, J. G.	Gravel	Mossley.
Grieves, John, M.P.P.	Gravel	Parkhill.
Graves, Geo.	Gravel	Leamington.
Harris, James	Gravel	R.R. No. 4, St. Marys.
Hill, Roland	Gravel	Crediton East.
Hunt, Alfred E.	Gravel	Bracebridge.

SOUTHWESTERN ONTARIO.—*Con.*

Name.	Material.	Address.
Hodgins, Geo.	Gravel	R.R. No. 1, Lucan.
Klopp, Elmer M.	Gravel	R.R. No. 2, Zurich.
Kirby, Henry	Gravel	Stratford.
Karr, James	Gravel	Petrolia.
Kerr, John	Gravel	Petrolia.
Kettle, Robt.	Gravel	Petrolia.
Kettle, Wm.	Gravel	Petrolia.
Lucas, Robt. J.	Gravel	Watford.
Litt, Geo. S.	Gravel	Sebringville.
Mills, James	Gravel	R.R. No. 3, Stratford.
Malloy Bros.	Gravel	R.R. No. 1, Sebringville.
Moody, Wm.	Gravel	R.R. No. 3, Exeter.
Morrison, W. E.	Sand	Ridgetown.
Munroe, John L.	Gravel	R.R. No. 1, Cairo.
Mawson, Mrs. Agnes	Gravel	R.R. No. 8, Parkhill.
Merner, J. J.	Gravel	Zurich.
McRann, Samuel	Gravel	R.R. No. 1, Clandeboye.
McShedran, John	Gravel	R.R. No. 3, Petrolia.
McKay, Wm., Sr.	Gravel	R.R. No. 2, Stratford.
Park, John S.	Gravel	Lucan.
Parish, Thomas	Gravel	R.R. No. 2, St. Thomas.
Rice, Geo. A., & Sons	Sand	Dresden.
Richards, Jos.	Sand	Dresden.
Robinson, Wm. J.	Gravel	R.R. No. 1, Crediton.
Rollins, John	Gravel	R.R. No. 1, Crediton.
Riehl, George	Gravel	R.R. No. 1, Sebringville.
Roadhouse, Mrs. Margaret	Gravel	R.R. No. 5, Stratford.
Smith Bros.	Gravel	R.R. No. 1, Cairo.
Sherman, Mrs. Wm.	Sand	Thamesville.
Stevens, Marshall A.	Gravel	St. Marys.
Smith, J. W.	Gravel	Leamington.
Showler, Geo.	Gravel	R.R. No. 1, Dorchester.
Smithers, Wm.	Gravel	R.R. No. 8, Parkhill.
Smith, Wm.	Gravel	R.R. No. 4, Thorndale.
Schwartzentrauber, Jacob	Gravel	Wyoming.
Siemon, Conrad	Gravel	Zurich.
Turtle, Samuel	Gravel	R.R. No. 1, Aberfeldy.
Tiffin, Arthur	Gravel	R.R. No. 1, Thamesville.
Triebner, Frank	Gravel	R.R. No. 1, Exeter.
Varley, Walter	Gravel	R.R. No. 8, Parkhill.
Watts, Wm.	Gravel	Thamesville.
White, Wm. M.	Gravel	R.R. No. 5, St. Marys.
Whitlock, Peter	Gravel	R.R. No. 1, Hensall.
Wood, John	Gravel	Exeter.
Windsor, Essex & Lake Shore R'y.	Gravel	Kingsville.
Windsor Sand & Gravel Co.	Gravel	Walkerville.
Wooley, John N.	Gravel	R.R. No. 3, Petrolia.
Whiting, Robt.	Gravel	Copleston.
Weber, Arthur	Gravel	Dashwood.
Walper, Louis	Gravel	R.R. No. 3, Dashwood.
Watson, John	Gravel	Bracebridge.

IRON DEPOSITS OF HUNTER ISLAND

with Notes on the

Gunflint Lake Area

By ARTHUR L. PARSONS

Introduction

In accordance with instructions from T. W. Gibson, Deputy Minister of Mines, the writer, accompanied by his assistant, Ellis Thomson, left Toronto on May 31st for Fort Frances, where provisions were secured, for an exploration of the iron ranges of Hunter island, Rainy River district. At Fort Frances, the party was joined by N. McDougal, who acted as canoeman during the season.

The work was impeded by extremely unfavourable weather, so that in many cases the ranges could not be examined in such detail as was desirable; more particular attention, however, was paid to the ranges which appear to give most promise of successful economic development.

The larger part of the work was on the range located on This Man lake and the lakes lying in the same rock trough. The ranges extending from Carp lake to Jasper lake were also studied carefully, but in less detail than the first mentioned deposit, while the final work on the Hunter island deposits was devoted to an examination of the magnetite deposits on the north shore of Saganagons lake.

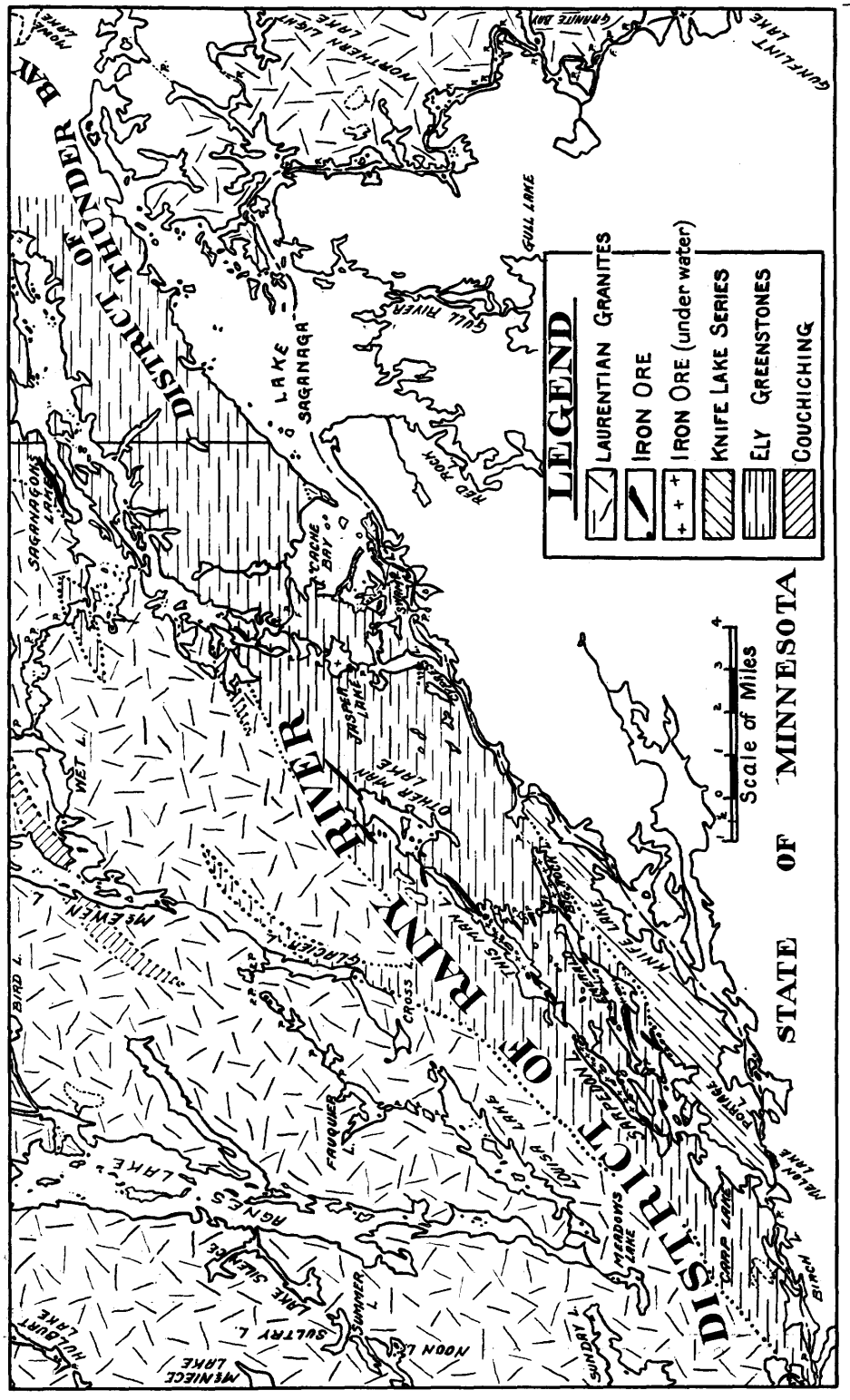
During the latter part of August a hurried examination of the outcrops of iron formation in the Gunflint area was carried on.

At present, the iron deposits of Hunter island can be reached in summer only by a canoe journey from North Lake, Fort Frances, or Kawene stations, on the Canadian Northern Railway. The best route is probably the one from North Lake, by which, with favourable weather conditions, the journey can be made in two or three days. The approach to This Man lake and Sarpedon lake from the southwest is difficult, as the region around Carp lake and the southwest end of Sarpedon lake has been burned within a few years, and the portages, which were never easy, have been made almost impassable. A safer, but still difficult, route may be taken from Emerald lake through a small mountain lake to the upper end of Sarpedon lake. With the exception of these few portages, the route is easy, as the portages are well cut out and good camping places are to be found on most of them.

Previous Geological Work in the Area

The literature relating to the geology of the Hunter island iron deposits is, considering the size of the deposits and the nearness to the old Dawson route, surprisingly meagre, and detailed work of importance is limited to the Report on Hunter island by W. H. C. Smith,[1] and the Report on the Vermilion Iron Range by J. Morgan Clements.[2]. Both these reports are accompanied by maps. In

[1] Geol. Sur. Can., Vol. 5, 1889-90-91, Part "C."
[2] U. S. G. S., Mon. XLV., 1903.


LEGEND
LAURENTIAN GRANITES
IRON ORE
IRON ORE (under water)
KNIFE LAKE SERIES
ELY GREENSTONES
COUCHICHING
Scale of Miles
STATE OF MINNESOTA
DISTRICT OF RAINY RIVER
DISTRICT OF THUNDER BAY
LAKE SAGANAGA
GULL LAKE
GULL RIVER
NORTHERN LIGHT LAKE
GUNFLINT LAKE
SAGANAGONS LAKES
WET L.
BIRD L.
CROSS L.
FAUQUIER L.
NOON L.
SUNDAY L.
MEADOWS LAKE
LOUISH LAKE
MELAIN LAKE
BIRCH
LARGE LAKE
MANITOU LAKE
SUMMER
SULTRY L.
LAKE SILVER
MANITOU LAKE
MANITOU LAKE
MANITOU LAKE

Smith's map the major part of the island is mapped as Laurentian with a large area of Couchiching on the northwest side connected with deposits of the same kind on Rainy lake, and an area of, approximately, equal size on the southeast side which is mapped as Keewatin. In this latter area he indicates numerous iron ore locations, but makes no attempt to indicate an iron formation distinct from the main mass of the Keewatin. In this report the deposits of iron ore are dismissed in a few words.

The report by Clements deals primarily with the great Keewatin area which contains the iron ore deposits in Minnesota known as the "Vermilion Range," and also deals with the Keewatin area on the southeast side of Hunter island. In his map, he subdivides this area outlined by Smith as "Keewatin" into five parts: Ely greenstones, Soudan formation, Ogishke conglomerate, Agawa formation and Knife Lake formation. The map is apparently, so far as the topography of the Canadian portion is concerned, an enlargement of Smith's map, and covers only the southern portion of the area.

Aside from these two reports, there is practically nothing published concerning the geology of the interior of Hunter island that has any bearing on the iron deposits, though much has been written descriptive of the geography of the region, particularly of the boundary chain of lakes. Among the latter class of descriptions may be mentioned the charming account of the region from Grand Portage, Minnesota, along the old boundary route, given by Sir Alexander Mackenzie.[3] The description of the route from Grand Portage to Basswood lake, which covers the part considered in this report, is reprinted in Clements' Report on the Vermilion Iron range.[4]

Topography

The area covered by this report is most emphatically one of lakes, the character of whose shore lines is determined largely by the nature of the contiguous rocks. Where Keewatin rocks are found, the shores are almost universally precipitous, and the lakes are likely to be long and narrow. In such instances the longer direction of the lakes is determined by the strike of the rocks or the general direction of schistosity. In the case of the lakes on the strike of iron deposits, there is good reason for supposing that they have resulted largely from the oxidation of the iron ores accompanied by a sinking, due to a decrease in bulk of the iron deposits. This is shown in a remarkable manner on This Man lake and Sarpedon lake.

Where granite rocks predominate, the shore lines are not so rugged. Sand beaches are more common, and the hills have a more gentle slope and rounded contour. In the absence of definite outcrops, the character of the underlying formation can usually be judged by the contour of these hills and the presence of sand beaches. This is, however, not always the case, as sand beaches are occasionally found near the head of lakes in the Keewatin rocks, but in such cases the sand is probably derived from the quartz accompanying the iron formation.

[3] Voyages from Montreal, on the River St. Lawrence, through the Continent of North America, to the Frozen and Pacific Oceans, in the years 1789 and 1793, by Alexander Mackenzie, London, 1801.

[4] U. S. G. S., Mon. XLV, pp. 57-63.

Laurentian

The Laurentian rock in this region is characteristically granite, and is easily recognized by the rounded dome-like character of its outcrops. In the iron region proper, very few outcrops of granite are to be found, but a short distance to the northwest the whole region is characterized by its presence. It does not come into the consideration of the ores, except on Saganagons lake, though contact features may be seen on Saganaga lake. There is, apparently, no good reason to assume for the granite northwest of the iron deposits an age different from that of the granite of Saganaga lake, but as this latter mass is traced to the east along Gunflint lake, where it is found very near, if not in contact with the Animikie, the relationships of these two are at times somewhat puzzling, and point to the possibility of a much later date for this granite than has heretofore been suggested.

Keewatin and Huronian

In the work of Smith, the series, which was later subdivided by Clements, was all mapped as Keewatin. In doing this, he undoubtedly followed Lawson who worked with a similar series on the Lake of the Woods and on Rainy lake. In those areas the principal subdivisions of the Keewatin are the greenstones and green schists, and the quartz porphyries and hydromica or sericite schists, with large masses of agglomerate and clay slate.

Clements subdivides the rocks, which are classed by Smith as Keewatin, as follows--

LOWER HURONIAN	Knife Lake formation Agawa formation Ogishke conglomerate
ARCHEAN	Soudan formation Ely greenstone

In the map accompanying Clements' report, all these formations are shown in the area under consideration, but by far the most important, considering the area covered, are the Ely greenstone and the Knife Lake formation. The Ogishke conglomerate was not recognized by the writer, and is evidently, from Clements' mapping, of insignificant proportion on Hunter island, though covering large areas in Minnesota, near Ogishkemuncie lake. The Soudan formation and the Agawa formation cannot be distinguished by petrographic means, but depend for their differentiation upon their stratigraphy.

The committee on pre-Cambrian nomenclature recognized the validity of the classifications in their principal features of both Lawson and Clements, and, later, Van Hise in correlating the pre-Cambrian rocks of the Lake Superior region definitely correlates the Ely greenstones and the Soudan formation with the Keewatin [5] while keeping the same subdivisions for the upper series.

In the region under discussion, the outstanding features are that there are two series of rocks which usually may be distinguished in the field by the colour of the weathered surface. One of these, the Knife Lake formation, is usually light coloured on the surface, though dark on an unweathered surface, while the other, the Ely greenstone, is dark both on the weathered and unweathered material. In

[5] U. S. G. S., Bull. 360, p. 328.

both these formations bodies of iron ore are found, but in their petrographic features no distinction can be drawn between Soudan iron formation and Agawa iron formation. The deciding criterion is stratigraphy, and for this it would seem to be necessary to find the Ogishke conglomerate. This conglomerate was not recognized by the writer, although indicated in Clements' map in the vicinity of This Man lake.

The field distinction between the Knife Lake series and the Ely greenstones in the vicinity of This Man lake and Sarpedon lake is not clear, and this difficulty is recognized by Clements for the region around Carp and Birch lakes. In consequence, the writer in mapping the region has adopted the following divisions for the Keewatin and Huronian:—

Knife Lake formation
Iron formation
Ely greenstones

Couchiching

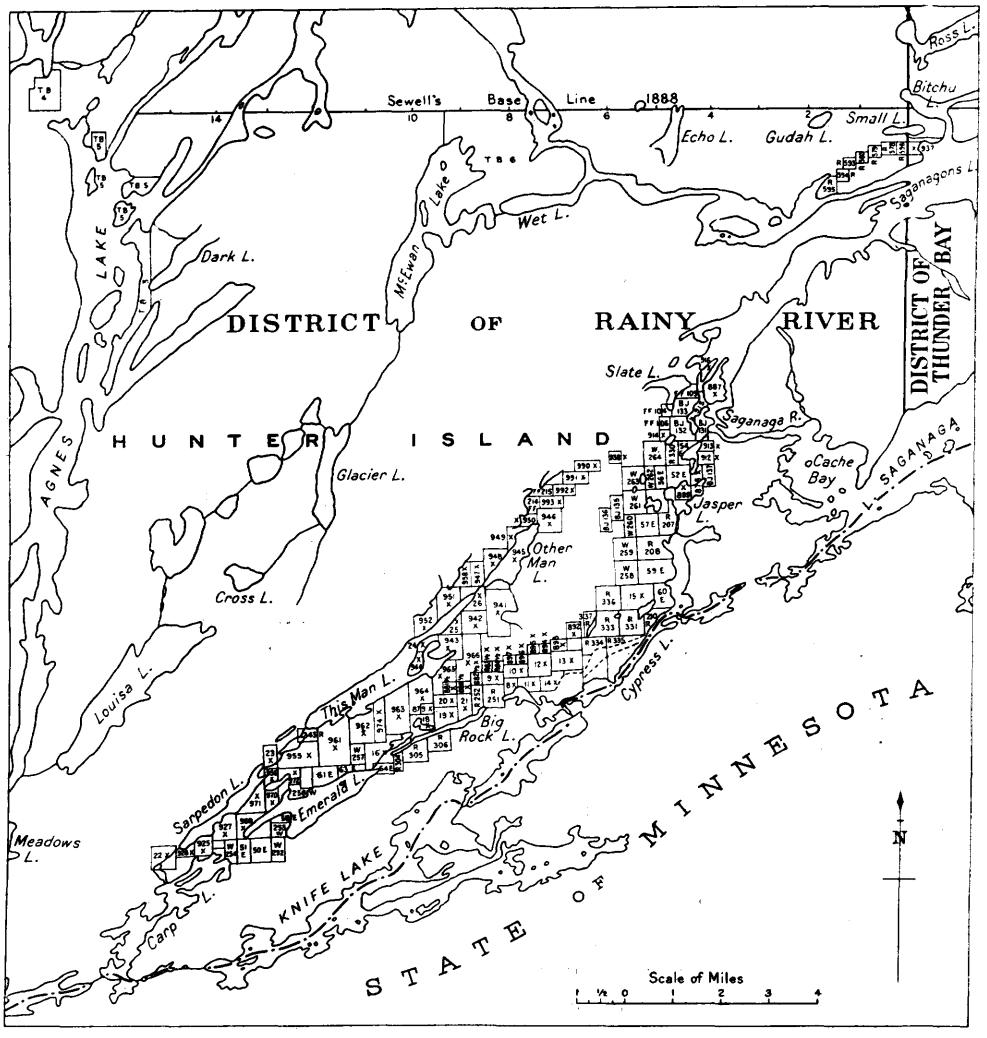
In mapping the Couchiching in the area under consideration, the writer has followed Smith's map. The only area examined is the one on Slate lake, which Smith maps as Couchiching, but in a note explains that the rocks are "characterized by the presence of muscovite as a constituent mineral." The other area on McEwen lake was not visited, as iron was not known to be present here, and the probability of its occurrence seemed slight. The rocks are highly metamorphosed and are principally mica schists.

Iron Deposits of Hunter Island

The iron ores of Hunter island and the north side of Saganagons lake are of three types, banded magnetite, banded hematite and carbonate. Of these, the carbonate would appear to be the original ore, though found in only two places; on a small island in This Man lake, and on a large island on the Minnesota side of Knife lake. These bodies of carbonate are not of pure siderite, but rather a ferruginous limestone or dolomite. The relations of this latter outcrop were not traced, but the former was correlated by dip needle readings and the strike of the formation with the principal range of iron ore on This Man lake. It is not possible to assert positively that it is part of this main ore body, as dip needle readings on siderite bodies are frequently not high, and on ferruginous limestones the readings might be disregarded, so that in many cases no definite indication can be secured in this way. In the case of the carbonate bodies, no marked banding was observed and almost no quartz. Such quartz as was present was white or light coloured and appeared to be vein quartz which is possibly of a later generation.

The other two ores are all more or less banded and, with few exceptions, consist of hematite or magnetite, or both, interbanded with red jaspilite and some vein quartz. The deposits on the north shore of Saganagons lake consist of magnetite with light coloured quartz, which has very much the character of vein material.

In estimating the value of iron deposits an approximation can be made by measuring the width of the iron bands and those of silica. In case the bands of silica are wider than those of the iron, it may safely be said that the ore body is of



Map showing mining claims on Hunter island.

low grade, and cannot be worked at a profit unless the bands of ore are so wide that a fairly clean product can be obtained by mechanical separation. This serves as negative information. Positive information concerning the value of a deposit can be obtained only by a chemical analysis, even in the case of bodies of ore which show no particular banding.

This Man Lake

This lake, which is about four and a half miles long, and at its widest point approximately a half mile wide, is bordered by rugged shores which, for the most part, are decidedly precipitous. The iron ore is principally confined to the south-east shore and the lake bottom, and it outcrops on the following claims:—R-343, 928-X, 968-X, 944-X, 24-X, 25-X, and 26-X.

The ore is in almost vertical position, and consists principally of hematite, jaspilite and vein quartz with some sericite and chlorite schists, and extends in a straight line from the southwest end of the lake to the southern shore of the northeast end. The continuity of the deposit is shown by the dip needle readings between the outcrops. On a small island near the middle of the lake and on the line of strike of the deposit, the oxidized ore is lacking, but in its place ferruginous limestone, which is oxidizing to limonite, is present. In addition to the main body of iron ore, insignificant outcrops of iron formation not more than ten feet wide were seen on the northwest shore of the lake and in a bay on claim 943-X. Samples from the main ore body were taken, and analyses have been made to show the character of the ore. Descriptions of individual claims follow. In some cases more than one deposit is found on a claim, but although an effort has been made to locate all these on the map no deposit less than twenty feet wide is described, unless it shows more than ordinary richness, or is of importance in its relation to larger bodies.

In the field, the writer supposed that the ferruginous limestone could be looked upon as siderite, and took a sample for analysis, the result of which is as follows:—

SiO_2	FeO	Fe_2O_3	P	S	Ti	CaO	CO_2	MgO	Fe
47.32	7.68	11.34	.063	.501	nil	3.74	8.45	1.67	13.91

The silica percentage in this is so great as to render the material of no value either as an ore or a flux.

Claim R-343.

In two places the ore body in this claim is easily seen, on the shore of This Man lake and on the portage between this lake and Agawa or Buzz lake. The outcrop on the shore is covered with moss and trees and, in places, a shallow mantle of soil so that it was impossible to expose the full width of the deposit with the facilities at hand. The ore was, however, exposed by stripping the moss to a width of forty-six feet, which is the smallest measurement obtained on the outcrops of This Man lake. On the portage between This Man lake and Agawa lake the full

width of the formation is exposed on a rather steep incline. Estimating the elevation from the lower edge to the top as forty feet, and measuring the width on the slope as one hundred and sixty-seven feet, the actual width was determined to be about one hundred and sixty-two feet; being the widest exposure seen in the entire district. There are several minor bands of greenstone and green schist in this outcrop, but the width of ore and jasper is about one hundred and twenty-five feet.

During a previous visit to this claim in 1904, the writer took from the claim a sample of ore which was analyzed by Prof. C. F. Sidener, of the University of Minnesota, with the following result —

SiO_2	FeO	Fe_2O_3	Al_2O_3	P	S	Ti	Undetermined	Fe
30.50	20.81	41.32	3.55	.148	.009	.15	3.513	45.74

Claim 928-X.

This claim is shown in Figure 1, being the island in the foreground at the right. It is about one hundred and fifty feet wide, and from four hundred to five

Fig. 1.—This Man lake from outcrop of ore on R-343. The island in the foreground is 928-X and is nearly all iron ore. The range follows the shore of the lake at the far end, and a line of islands at the southwest end.

hundred feet long. Approximately two-thirds of the width of the island is banded iron ore, consisting of hematite and jaspilite.

Two samples of the ore were taken, one (No. 5) being considered a fair average of the deposit as a whole, while the other (No. 6) is from one of the richer bands. The analyses follow:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	Co_2	Fe
No. 5	48.24	8.44	35.28	.102	.002	nil	.49	31.26
No. 6	37.60	6.30	51.52	.061	.423	nil	.59	40.96

Claim 968-X.

The ore on this location is a continuation of the body on R-343 and 928-X, and appears at the water's edge. From the contact with the schist wall on the southeast side of the ore body to the water's edge, the width is sixty feet. The formation as a whole at this point appears to be low grade, but in some of the depressions in the ore body higher grade material was present. In the midst of the ore body some bands of green schist were found, and in this schist veinlets of jaspilite were seen filling cross fractures. In some parts the ore is much brecciated, but the writer could find no evidence of a corresponding brecciation in the adjoining schists and greenstones. This is a feature which is observed very commonly in the ores of the region.

Sample No. 18 is thought to be a fair average of the outcrop on this claim, and the analysis which was made by W. K. McNeill, Provincial Assayer, is supplemented by an analysis (No. 20) made in 1904 for the writer by Prof. C. F. Sidener, of the University of Minnesota:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Al_2O_3	Undetermined	Fe
No. 18 (1915)	55.40	9.70	21.42	.157	.041	.....	1.02	....		22.55
No. 20 (1904)	44.45	12.69	28.45	.123	.013	.10	....	6.56	7.614	29.8

Island N. E. of 968-X.

In direct line with the outcrops on 928-X and 968-X is an island about equal in size to 928-X, which exhibits the continuation of the ore body. The ore is hematite, and is located on the nothwest side of the island. The width of the better grade ore is about forty feet, but adjoining this is a banded schistose material containing considerable ore, but hardly good enough to be of economic importance, which, with the ore, makes a total width of ninety-four feet. The island is about six hundred feet long, and the ore extends the entire length. One sample was taken for analysis, and the results obtained by W. K. McNeill, Provincial Assayer, are given herewith:—

SiO_2	FeO	Fe_2O_3	P	S	CO_2	Ti	Fe
40.25	12.60	45.92	.102	.219	.43	....	41.94

Although this is not a high-grade ore, it is equal in quality to some of the Lake Superior ores which have been shipped in large quantity.[6]

The deposits at the northeast end of the lake are upon claims Nos. 24-X, 25-X, 26-X, 942-X, 943-X and 944-X. The ore body merely cuts across the corners of 942-X and 943-X, and was not traced into 26-X, but is well exposed along the

[6] Crowell and Murray. The Iron Ores of Lake Superior, 1914, pp. 183, 188, 226, 244.

shore on 25-X and 944-X, and outcrops at the lake shore at the west end of the line between 24-X and 944-X, and another outcrop of about the same quality as the ore on 944-X and 25-X was seen on the shore near 25-X. Samples to represent this portion of the range were taken on 944-X and 25-X, as the ore body is better exposed and it was possible to get a more representative sample.

Claim 944-X.

The ore body on 944-X consists of banded jaspilite and hematite with probably some magnetite, as the dip needle is much affected. The northwest boundary of the ore, being beneath the lake, could not be located, but a width of fifty-four feet was measured across the ore from the southeast wall to the lake shore. The ore

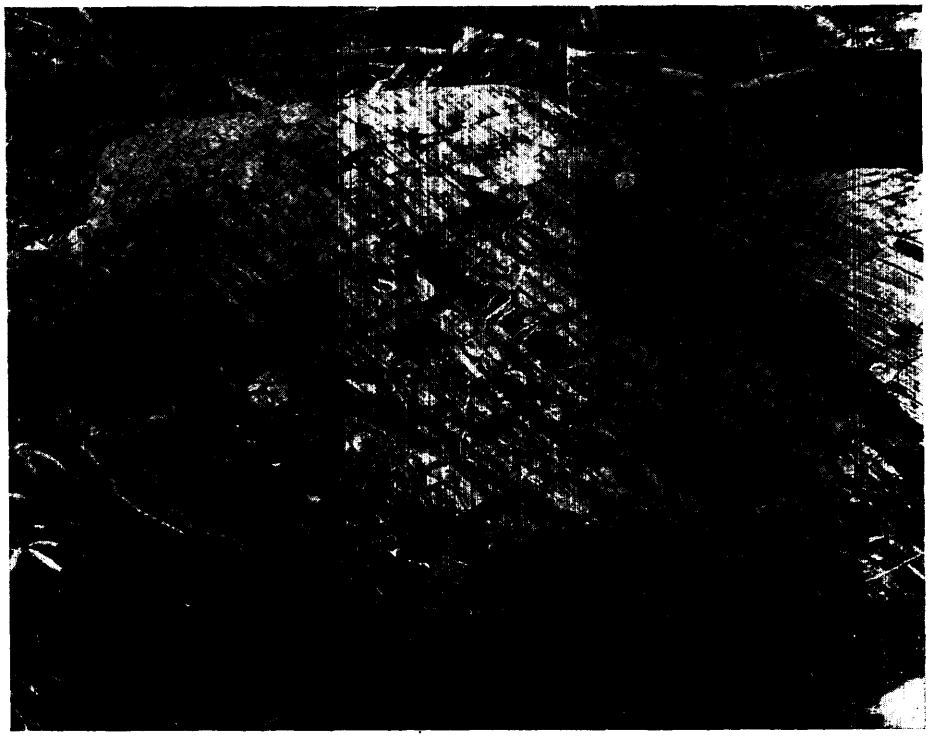


Fig. 2.—Banded hematite on claim 944-X.

bands are broad, and about two-thirds to three-fourths of the width exposed appears to be good ore. The low-grade material is principally jaspilite, and would be separated easily on a picking belt. The ore body at this point is on the lake shore, and jaspilite was seen under the water at least forty feet from shore, so that the total width of ore in this band is not less than ninety feet. The banded character of the ore is shown in Figure 2.

Three samples of the ore were taken for analyis from the better portions of the outcrop and have been analyzed by W. K. McNeill, Provincial Assayer, with the following results:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
No. 10	44.33	9.80	34.58	.081	.182	nil	.58	31.85
No. 11	41.06	5.29	51.38	.143	.004	nil	.24	40.08
No. 12	37.96	9.32	44.94	.059	.118	nil	.16	38.71

Of these, No. 10 is too low grade to be of value, but numbers 11 and 12 come within the limits for iron and silica that are found in actual shipments from Lake Superior ports.

Claim 24-X.

There is a showing of iron ore at the lake shore at the corner between 944-X and 24-X, as well as on the northeast side of the claim near 25-X. This claim was not sampled, there not being sufficient difference in the character of the ore from that found in the two adjoining claims to make it necessary or advisable.

Claim 25-X.

The continuation of the ore body seen on 944-X and 24-X is found on 25-X, and consists as on the other claims of hematite and jaspilite. Apparently the ore is of good quality, though there is considerable jaspilite. This, however, could easily be removed on a belt. The best portion of the ore body consists of a band of hematite about fifteen feet wide (Sample 15). In places, vein quartz is present with the jaspilite, and nodules of the same material were seen in the ore near the wall. The width of the entire outcrop is sixty-one feet. Some green schist is present in the midst of the ore body, but in comparatively small amount.

Three samples were taken for analysis, and the results obtained by W. K. McNeill, Provincial Assayer, are shown below for samples Nos. 13, 14 and 15. To these is added an analysis made by Prof. C. F. Sidener of the University of Minnesota for the writer in 1904, of material from the same claims:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Al_2O_3	Undetermined	Fe
No. 13	41.9	16.0	37.10	.210	.135	nil	.65	....	....	41.24
No. 14	46.50	12.34	37.52	.186	.008	nil	1.15	....	....	35.86
No. 15	31.85	9.95	41.72	....	....	....	....	....	....	36.95
1904	29.75	8.40	57.10	.072	.023	.01	....	3.75	2.608	46.06

Next Man Lake.

At the northeast end of the portage between This Man lake and Next Man lake is a large outcrop of low-grade iron ore. The relations between this deposit and the main range on This Man lake are uncertain, but the deposit appears to extend towards the north side of This Man lake rather than towards the ore body on the south side. At the northeast end of Next Man lake, the iron formation again outcrops and extends through claims 946-X, 993-X, 992-X and presumably through 991-X and 990-X, but the writer did not trace it beyond 992-X. At this point, the body of iron ore is very lean, and, as it would not be of commercial value

Fig. 3.—Island on Next Man lake, showing sericite schist in foreground, and iron ore in background. The small pole lying on the rock in the foreground is parallel with the planes of schistosity, while the pole lying on the ore near the water's edge is parallel with the banding of the ore.

without mechanical concentration, no samples were taken. About the middle of the lake, almost in line between these two outcrops, is an island upon which the iron formation is found (see Figures 3 and 4), but strangely enough the strike of the formation is northwest-southeast instead of northeast-southwest. If this belongs to the same range as the other two, there is evidently a decided fold in the formation. This, however, cannot be verified. Upon this island, the adjoining rock is somewhat schistose, and the planes of schistosity are in a northeast-southwest direction. The outcrop of ore and rock on this island is shown in Figures 3 and 4.

Going over the portage between Next Man lake and the small lake shown west of claim 950-X, another range of iron ore is found near the end of the portage on 949-X. This range is known to extend through 949-X, 948-X and 947-X. It is,

Fig. 4.—Iron ore seen in Fig. 3.

however, only about twenty feet wide, and of low grade. An analysis made by Professor C. F. Sidener of the University of Minnesota of a sample taken from 948-X, for the writer in 1904, is given below:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	Al_2O_3	Undetermined	Fe
No. 25 (1904)	27.30	15.77	48.26	.142	.007	.15	5.83	2.541	46.06

This analysis, however, does not represent an average of the deposit, but may be looked upon rather as the product that might be obtained by crushing the ore and concentrating by a magnetic separator. The sample from which the analysis was made was from one of the bands of magnetite. An average of the whole deposit would show a much lower iron content. If, after crushing, the ore were put through rolls, it is probable that a much higher grade ore might be secured, but in view of the limited extent of the ore body, it is doubtful whether this would be commercially feasible. The ore of this deposit consists of magnetite and nearly black quartz, which gets its black colour from a small quantity of disseminated mag-

netite. It resembles the deposit on the north side of Saganagons lake, except that the latter deposit contains more white quartz that would ordinarily be called vein quartz.

So far as the writer is able to judge, the iron bodies on Next Man lake will not be of economic importance for some time.

Sarpedon Lake.

The outcrop of iron ore on Sarpedon lake is of a character that gives promise of value only when its relation to the other parts of the same range is considered. Several minor bands of banded iron formation are to be seen in the region between this lake and Emerald and Carp lakes, and some of these outcrop on the southeast shore of Sarpedon lake. The most important band of ore, however, outcrops near the southwest end of the lake and extends to the next lake to the southwest. This band consists in part of sericite schists with siderite, and in part of hematite and magnetite interbanded with quartz. It is doubtful whether any of the outcrops

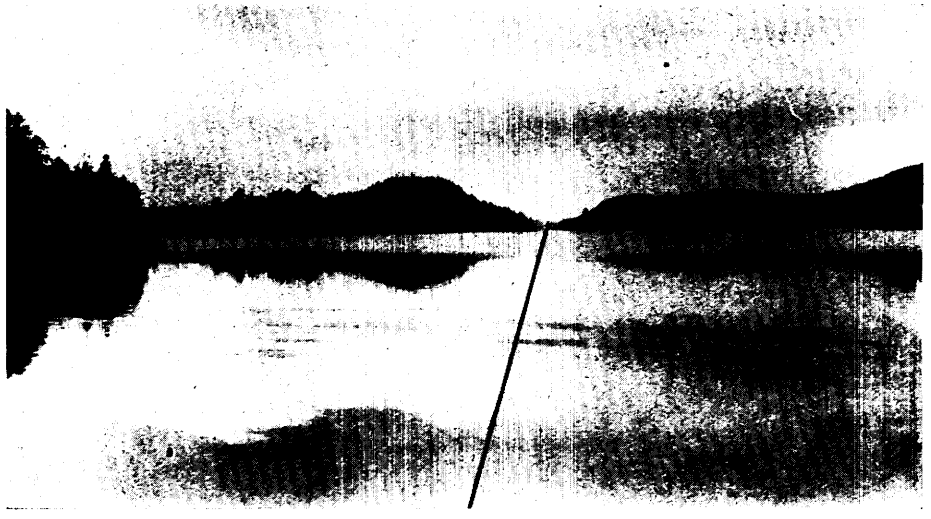


Fig. 5.—View from the head of Sarpedon lake.

are sufficiently rich to warrant exploitation, but the lake itself offers a field of considerable promise. At the northeast end of the lake, no outcrop of ore was seen that could be looked upon as an extension of the deposits on This Man lake, but it was found that dip needle readings from 45° to 90° were obtained on crossing the lake at this end. The lake was then traversed by canoe in a zigzag, and it was assumed that a dip needle reading of more than 45° indicated a body of iron ore. In this way it was considered that a good-sized body of ore may extend from one end of the lake to the other with a maximum width of not more than two hundred feet and a probable minimum of seventy-five feet. The direction of this ore body is shown in Fig. 5, which is a view taken from the northeast end of the lake and showing the hills at the far end. The line which has been drawn on the surface of the water indicates the direction of the ore body, and the narrows between the

large island and the mainland on the right is somewhat more than the maximum width of the ore body. The length of this line is, approximately, three and one-half miles. As will be seen by reference to the map this body of ore is directly in line with the outcrops of hematite on the southeastern shore of This Man lake, and although the writer did not locate an outcrop on the southwest shore of Agawa lake there appears to be no good reason for looking upon this as other than the continuation of the well-exposed deposits of This Man lake. Strangely enough the area underlying Sarpedon lake has apparently never been taken up as a mining claim, though all the area between this lake and Emerald and Carp lakes has been surveyed into mining claims. These latter, while showing bands of iron formation, are not promising. In no case was an outcrop found of sufficient magnitude or purity to warrant development, and so far as could be ascertained, little development work, if any, has been done. In fact, the amount of development in the entire area, with a few exceptions which will be noted in the proper place, is negligible. This is due to the fact that the principal deposits when they are above water are usually well exposed near the water's edge, or are covered with a thin growth of moss.

If we assume this deposit in Sarpedon lake to be continuous for the entire length of the lake with an average width of seventy-five feet, and having a specific gravity of four or a weight of two hundred and fifty pounds per cubic foot, which is probably the minimum for commercial hematite, we find a total of 173,250 tons for each foot in depth. When we consider the constancy of the deposit on This Man lake, together with the elevation of some of the outcrops, there seems to be no good reason for estimating a depth of less than one hundred feet on the oxidized ore. This supposition of the size and value of the ore body, however, can be proven only by diamond drilling, but the existence of the ore body is not to be doubted.

Area Between Sarpedon and Carp Lakes.

Claim 22-X, which is on the shore of the small lake between Sarpedon and Carp lakes, shows two outcrops of iron formation, the smaller one at the point indicated by Clements, the larger one in line with the Sarpedon Lake deposit. The first of these is too small to be of economic importance, while the latter is a lean ore, though more than a hundred feet wide. To be of value, this material would have to be concentrated, and with the large reserve of higher grade material this is economically possible only in exceptional circumstances. The extension of this deposit to the southwest could be located for only a very short distance, and no further outcrops of commercial ore were located in that direction.

Pewabic Lake.

Pewabic being the Indian name for iron, it was thought that an outcrop of ore might be found on this like, but a careful examination of the shores failed to show any except a band of siderite about three feet wide in schist near the outlet. Traversing the lake with a dip needle gave no indication of a body of ore.

Area Between This Man Lake and Emerald Lake.

In the area south of This Man lake and north of Emerald and Big Rock lakes, there are several small deposits of iron ore ranging in width from 4 or 5 feet to 25 or 30 feet. These, however, are all of low grade, and give little promise of being commercially important in the near future.

Carp Lake.

On Carp lake, which is on the boundary between Canada and the United States, there are three bodies of iron formation, only one of which, however, is of any possible economic importance. These three bodies are shown on the map, the

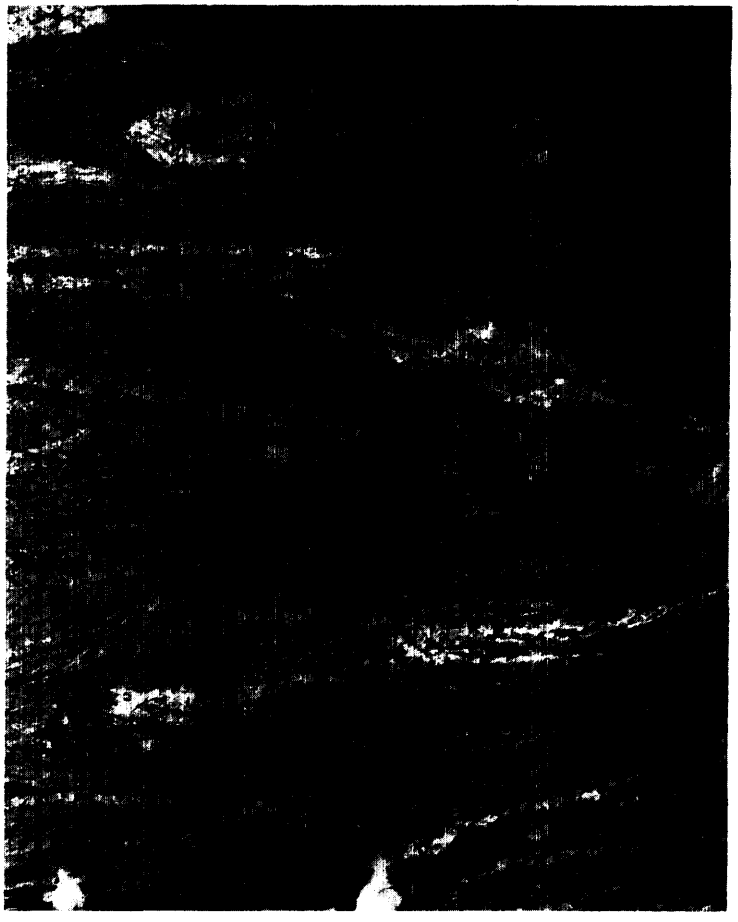


Fig. 6.—Folded iron ore, Merritt's camp.

first being on the northwest side nearly in the line of strike of the Emerald Lake deposit. On Carp lake this body is not more than ten feet wide, and decidedly low grade. The second indication of iron formation is immediately to the south of this on a small island, and also on a point of the main line where a yellowish,

rusty outcrop indicates the presence of a low-grade ferruginous carbonate of no economic importance. The third body is in a bay at the east end of the lake, which is known as Merritt's camp, where there is a large body of much contorted banded iron ore which is somewhat V-shaped in its outcrop. This is one of the few locations upon which any trace of development work is to be found. Several trenches and pits were opened up, and in the summer and autumn of 1904, the property was drilled. The ore body is much folded and contorted without a corresponding contortion in the adjoining rock. The V shape of the outcrop probably indicates a major folding here, but this is not sufficient to account for the wonderful crumpling in the ore when no such plication is shown

Fig. 7.—Folded iron ore, Merritt's camp.

in the adjoining rocks. This crumpling is shown in Figs. 6 and 7, which also show well the character of the ore. Inside the V is a knob of porphyritic rock of light colour. The width of the ore body from the contact with the porphyry to the lake shore measured on a slope of 19° is 153 feet, which is equivalent to a width of 141 feet on the level. This ore body appears to be an isolated one, and no connection could be found between it and the deposits on Emerald lake with which it might be supposed to be connected. On account of the banded character of the ore, it was difficult to obtain a fair sample, but the sample taken for analysis was thought to be fairly representative. As will be seen in Fig. 7, the ore is made up of bands of ore and silica of comparatively narrow width. On

this account it would yield a product that would be rather expensive to concentrate if the ore did not come up to the expected grade. A sample was taken for analysis, and the results obtained by W. K. McNeill, Provincial Assayer, are given below—

SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
61.76	10.44	11.41	.145	.261	nil	1.25	16.12

This analysis confirms the estimate that can be deduced from the photographs.

Emerald Lake.

In Emerald lake, there are two, and possibly three distinct bands of iron formation. These are indicated on the maps of both Smith and Clements. The most important of these outcrops is on E-58 and extends beneath the lake to the east shore, cutting on the way a small island. The extension under the lake was located by the dip needle, but no outcrop was found on the east shore. There is, however, a valley between the overhanging cliffs which probably represents this formation. To the southwest of E-58 the banded ore and jaspilite are replaced by a cellular sericite schist with vein quartz, and farther along by siderite sericite schist.

On claim E-58 is a very striking outcrop of banded iron ore, consisting of hematite and broad bands of red jaspilite. Although this is probably the most striking outcrop in the whole region on account of the beautiful colour of the jaspilite, the writer was unable to find a place where the deposit as a whole, or even in large part, is rich enough to be of economic importance under present conditions. The dip needle shows a continuation of this deposit to the northeast extending to an island about half a mile from the point on E-58, and thence nearly to the east shore of the lake, when no further reading could be obtained with the dip needle. Samples were taken on the island as the bands of silica are narrower, and it was thought that it might possibly be of a high enough grade to warrant exploitation. The analysis is given below:—

SiO_2	FeO	Fe_2O_3	P	S	Ti	CaO	CO_2	MgO	Fe
67.70	7.18	8.12	0.038	.16	nil	4.80	3.13	trace	11.27

As will be readily seen, this is altogether too low in iron to be of any importance.

Although the several indications are not particularly encouraging, it is worthy of mention, however, that diamond drilling, particularly under the lake, may show a body of much higher grade ore.

Big Rock Lake.

On the portage between Emerald lake and Big Rock lake, some fragments or pieces of iron formation were observed, but the outcrop could not be located. In traversing Big Rock lake, however, in a canoe, it was found that dip needle readings could be obtained nearly the entire length of the lake, and two outcrops of banded iron ore were located along the line of these dip needle readings, one of them on a point on claim R-305, the other on a similar point on R-306. The

Fig. 8.—Cliff of iron ore, showing major folds and rounded surfaces.

deposit, however, could not be traced to the shore at the northeast end of the lake, but the dip needle readings ceased about a half mile from the end of the lake. A sample was taken from the outcrop on R-305, and an analysis was made by W. K. McNeill, Provincial Assayer, as follows:—

SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
62.98	13.61	19.19	0.041	.17	nil	0.76	24.01

As will readily be seen the iron content is too small to be of economic value.

Otter Track Lake.

Banded iron formation was found in only one place on this lake, and is too limited in quantity to be of value. This outcrop is on the west side of the lake near claim 60-E. Although limited in its extent, it exhibits some remarkable folding and crumpling, as will be seen in Figs. 8, 9 and 10. In Fig. 8 major folding is shown, while in the others, the remarkable crumpling is seen nearer at hand, Fig. 10 being a closer view of part of Fig. 9. There is no good explanation, that occurs to the writer, of this remarkable crumpling, particularly as the iron ore alone is subject to this type of disturbance. The adjoining rocks show a more or less well developed schistosity parallel with the general strike of the iron ore form-

Fig. 9.—Near view of part of the outcrop shown in Fig. 8, exhibiting crumpling of iron ore.

ation, while the iron ore body itself is crumpled and twisted in all directions. Similar phenomena were noticed in other bodies of banded iron ore, but were always looked upon as minor folding, and possibly connected with great earth movements affecting the adjoining rock. It would appear, however, that this folding is intimately connected with some change in the iron ore itself, and it has occurred to the writer that it may possibly be due to the oxidization of an original carbonate with the formation of vugs containing more or less quartz, which, by a combination of vertical and lateral pressure have developed a structure simulating ordinary folding. The wonderfully contorted character of this

Fig. 10.—A closer view of part of the outcrop shown in Fig. 9.

Fig. 11.—Otter Track lake, looking northeast from United States side, near R-335.

outcrop was noted by H. V. Winchell,[1] but unfortunately his account was unaccompanied by photographs showing the remarkable character of the outcrops, though a drawing is given which represents a cross section of these more or less rounded masses.

The general character of the topography of the parts of the region covered by Keewatin rocks is shown in Fig. 11, which is a view on Otter Track lake.

Jasper Lake.

An outcrop of iron ore of low grade is found at the north end of the portage between Otter Track and Jasper lakes. The continuity of this deposit under the lake was not shown by dip needle readings, but nearly north of this point on 878-X and E-52 a body of banded ore shows up, which is about fifty feet wide. Two samples were taken which were thought to represent an average of the deposit, and analyses have been made by W. K. McNeill, Provincial Assayer, with the following results:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
No. 52	44.97	13.48	27.02	0.055	0.13	nil	0.78	29.40
No. 52-A	50.78	14.74	24.50	0.072	0.15	nil	0.56	28.50

Although not sufficiently high grade to be at the present time economically important, these are sufficiently rich to encourage further prospecting, preferably by diamond drilling, to see whether a higher grade material cannot be found in quantity.

Saganagons Lake.

Two bodies of iron ore were seen by the writer on this lake. The first is near the south end of the lake on claim 887-X. The outcrop consists of banded iron ore in a nearly vertical attitude, but appears to contain too much silica to make it of commercial value at the present time. The other deposit is on the north side of the lake north of the iron monument on the boundary line between the districts of Rainy River and Thunder Bay. Upon these latter claims considerable development work has been done; the timber has been cleared up to a width of about 100 feet along the outcrop of the iron formation, and numerous trenches have been opened up to show the extent of the body, and four pits have been sunk to as great a depth as possible without hoisting machinery. This is the best development work that was seen by the writer in the entire Hunter Island region. The width of the ore body would average about 25 feet. Two samples were taken

[1] Minn. Geol. & Nat. Hist. Sur., 17th Ann. Rep., pp. 111-115.

for analysis, which were thought to represent the average content of the ore body and the results of analyses are given below:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
No. 55	48.92	14.61	28.70	0.80	0.056	nil	0.39	31.45
No. 60	47.10	13.22	33.60	0.087	0.14	nil	0.61	33.81

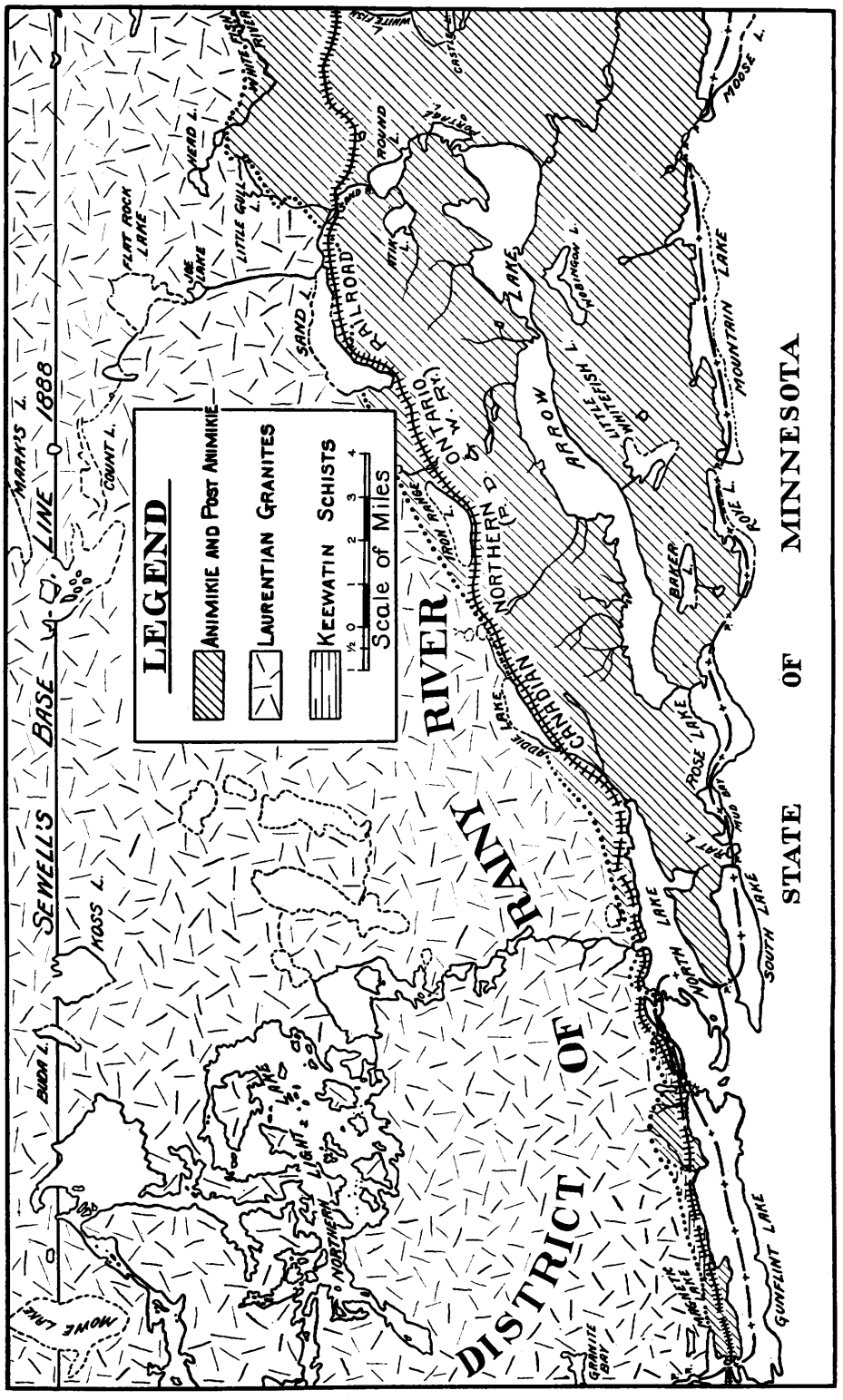
The ore of this place consists of banded magnetite and quartz, and although the grade is low, ore of similar grade, under favourable conditions, is concentrated by magnetic concentrators to make a high-grade product. The bands of quartz are quite distinct, and it should be possible to secure without difficulty a 50 per cent. product with minor losses in iron. The character of the ore body is very similar to that on 948-X, near Next Man lake.

Iron Deposits in the Gunflint Area

During the latter part of August, the writer made a hurried examination of the area between Gunflint lake and Whitefish lake to ascertain, if possible, the value of the Animikie iron formation in this locality. The existence of the iron formation on Gunflint lake has been known for nearly a century. Dr. John Bigsby, in 1824, mentioned the fact that "on Gunflint lake are considerable deposits in trap of jasper", this being one of the first references to the jaspilite of the iron ranges of the Lake Superior region.[8] This jasper, or jaspilite as it has been more recently called, is intimately associated with bodies of iron ore of greater or less purity. On Gunflint lake, the writer found no deposits that were of sufficient extent, or of sufficient promise, to warrant sampling for commercial purposes, but there was a deposit or low-grade carbonate near the western end of the lake in the Animikie or Rove lake series. Analyses of the iron-bearing carbonate show that it is extremely low grade, being for the most part high in silica, and in certain parts containing large amounts of calcium and magnesium carbonates.[9]

Owing to the fact that the iron-bearing member is largely covered with loose material brought down from the overlying deposits, the writer was unable to observe any considerable outcrops of a higher grade iron ore, which was a source of considerable diappointment, as high-grade ores have been reported from this region in the state of Minnesota, just a short distance west of Gunflint lake.[10] In going east from Gunflint lake small outcrops of iron formation were seen at various places, but nothing that gave promise of economic value was observed until the area of Whitefish lake and Round lake was reached. About midway between these lakes on the north side of the Canadian Northern Ontario railway, some stripping has been done on several claims belonging to Mr. McGugan, but as the owner was absent at the time of the visit, it was impossible to secure the numbers of the claims,

[8] Amer. Journal of Science, Vol. 8, p. 64.
[9] U. S. G. S., Mon. XIX, p. 192.
[10] U. S. G. S., Mon. XLV, p. 385.



Geological sketch map of Gunflint Lake area.

or even to know whether the most promising trenches had been visited or not. In the trenches visited the amount of iron ore was not great, and many of the pits had been partially refilled with débris, so that no fair estimate could be made, but the impression made upon the writer was discouraging. It is possible, however, that more thorough stripping would reveal an encouraging deposit. Samples of the best material that could be seen were taken, and the analysis of No. 128 made by W. K. McNeill, Provincial Assayer follows:—

SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	CaO	MgO	Fe
34.02	9.32	31.50	0.048	0.18	nil	5.30	13.50	trace	29.31

North of the west end of Whitefish lake, about a mile from the railroad, Messrs. Brown & Bishop, of Whitefish lake and North lake have done development work on several claims, with the result that they have exposed a body of low-grade iron ore, which appears to be from ten to fifteen feet in thickness. The stripping has been done on a nearly level spot, and consists of a trench about two hundred and fifty feet long, clearly exposing the surface of the ore body. It was, however, impossible to get exact data as to the thickness of the body. The ore body is overlain by taconite, and, underneath, jaspilite is exposed. Samples were taken, and the analyses were made by W. K. McNeill, Provincial Assayer, with the following results:—

	SiO_2	FeO	Fe_2O_3	P	S	Ti	CO_2	Fe
No. 131	32.98	3.53	54.04	0.054	0.15	nil	0.44	40.57
No. 132	45.00	4.28	40.88	0.043	0.19	nil	0.34	31.94

Sample Number 131 is of a grade that will pay for shipping, if found in sufficent quantity, but sample 132 is probably too low in iron and too high in silica, to be of commercial value.

A trip was made along the shores of Arrow lake to see whether any outcrops of iron-bearing members of the Animikie could be found, but without success.

The map showing this region is compiled from plans in the Surveys Branch of the Ontario Department of Lands, Forests and Mines, Ingall's Sketch Map of the Thunder Bay Mining region of Lake Superior,[11] and maps of Gunflint lake by A. Winchell,[12] and a map of Gunflint and part of North lake by W. N. Merriam.[13] No effort has been made to differentiate the Animikie and post-Animikie formations, as the post-Animikie consists almost entirely of diabase sills included in the Animikie, so that where this formation is present, it is reasonably safe to assume that the Animikie underlies it. The iron-bearing member is not exposed, except

[11] Geol. Sur. Can., N.S., Vol. III, Pt. H, p. 20, 1887-88.
[12] Minnesota Geol. Sur., 16th Ann. Rep., p. 236.
[13] U. S. G. S., Mon. XIX, p. 521.

in a few places along railroad cuttings or the shores of lakes and where trenching has been done for the purpose of developing the iron deposits. Much of the country has been burned over, so that it is extremely difficult to make an examination at any distance from the railroad or the water-courses. On account of the length of time that has elapsed since the surveys of this area were made, it is seldom that a corner post of a claim is found, in consequence of which it is difficult to locate the deposits on any particular claim. In mapping the formation on the north side of Gunflint lake, the writer has followed Winchell's mapping, so that it will be observed that there are two areas mapped as Keewatin. This material consists of highly altered hornblende schists in a vertical attitude near the outcrop of granite. The best exposure of this rock is found in a railway cutting just east of Gunflint lake, and the character of the exposure is well shown in the accompanying illustration, Fig. 12. The outcrop north of the central part of Gunflint lake is not so highly metamorphosed as the last mentioned, but shows some major folding with schistose development, and is shown in Fig. 13.

Fig. 12.—Keewatin (?) outcrop on railway east of Gunflint lake.

Water Powers

Along the international boundary between Rainy lake and Gunflint lake are numerous waterfalls which might easily be developed for the production of power. The heights of the falls are given in the "Report on the Exploration of the Country between Lake Superior and the Red River Settlement," by S. J. Dawson. As being more intimately connected with the iron deposits on Hunter island and the Gunflint area, it may be noted that at the outlet of Gunflint lake there are two excellent falls, the first about 21 feet in height, and the second about 46 feet. The higher of these falls was not seen by the writer, as the portage did not bring him within sight of the fall. The first one, however, is shown in Fig. 14, and is well

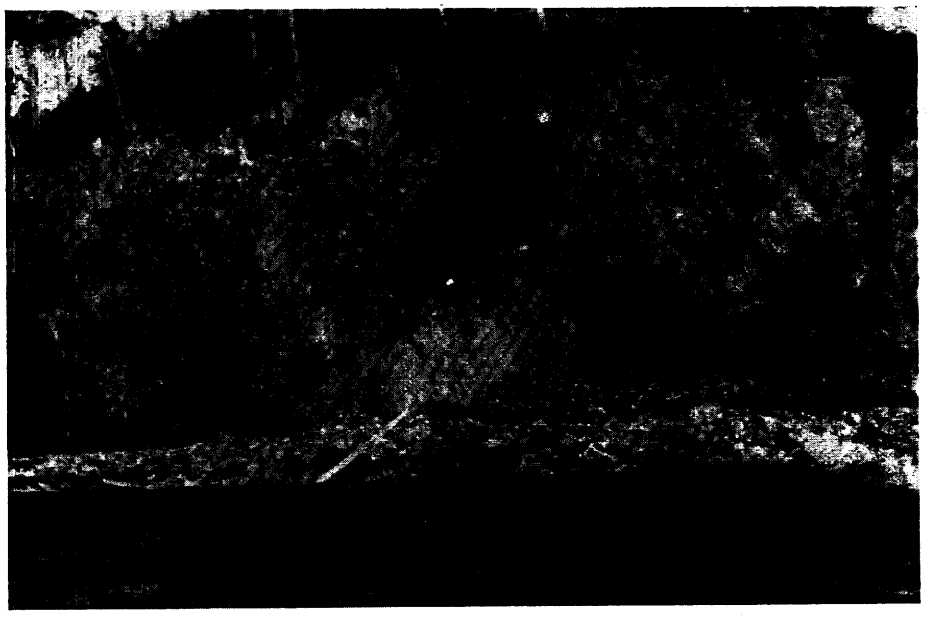


Fig. 13.—Keewatin (?) outcrop, showing major folding on north side of Gunflint lake.

Fig. 14.—Falls on the outlet of Gunflint lake.

adapted to the development of electric power. The other falls along the international boundary that are of importance are at the outlet of Carp lake, where there is a fall of about 27 feet, and at the outlet of Birch lake, where there is a fall of about 40 feet. In Dawson's profile, the lake that is now called Birch lake is given as Carp lake. Another fall of about 20 feet comes at the outlet of Knife lake, but as the writer did not go from Carp lake to Knife lake, he can say nothing about the possibility of utilizing this power. On the outlet of Saganaga lake, there is a magnificent waterfall, which is shown in Fig. 15. As the writer's aneroid was

Fig. 15.—Waterfall on the outlet of Saganaga lake.

injured in the summer, it was impossible to measure the height of this fall, but from the picture it would appear to be about 30 feet.

Smaller waterfalls which are of doubtful value in the development of power, as the watershed is of limited extent, are at the outlet of This Man lake and the small lake between Sarpedon and Carp lakes. The height of fall in these cases is sufficient, but the quantity of water is too small for an extensive plant. Another similar fall is found on the west side of Big Rock lake, but as this merely drains a portion of the area between This Man lake and Big Rock lake, it will readily be seen that the watershed is too small to furnish an extensive permanent water power.

Fish

The lakes along the International boundary are well stocked with fish, and on the American side, in the larger of these lakes, commercial fishing is carried on, but as far as the writer saw, no development of this important industry has been made on the Canadian side. The principal varieties of fish taken at these fishing stations are white fish, pickerel, pike, lake trout and sturgeon, the last being found in all the lakes from Rainy lake up to and including Lac LaCroix. The lakes in the iron region of Hunter island are well stocked with fish, principally pike, pickerel and lake trout, the last being of exceptionally fine quality. Hunter island lies wholly within the Quetico Provincial Park and in consequence comes under the Provincial Parks Act, which strictly prohibits all fishing within the park boundaries except with hook and line, and after obtaining a license for the privilege.

Game

Inasmuch as Hunter island forms a part of the Quetico Provincial Park, which is also a game reserve, it is natural to expect that there would be plenty of moose, deer, and other animals. The moose and deer are in comparative abundance, though the writer did not see a greater number than in the region around the Lake of the Woods. In addition, fur-bearing animals are quite abundant. Fox, fisher, mink and wolves are fairly numerous, while the porcupine, which can hardly be called a fur-bearing animal, is so abundant as to be a nuisance.

Forests

In going from Fort Frances to Hunter island, and thence to North lake, it is of interest to note that the forest on the Canadian side has, as a rule, not been injured by fire, and little of the timber has been cut. On the Minnesota side, except in the Superior National Park, practically all the forest has been cleared or burned. On Saganaga lake, however, and on Gunflint lake, the Minnesota side has not been stripped of its forest growth, probably owing to the fact that it is almost impossible to get the timber out of this area with present transportation facilities. The forests consist principally of spruce, balsam, banksian pine, red pine, tamarac, birch and poplar. The presence of tamarac in a thriving condition was a feature which impressed the writer most forcibly, inasmuch as in other regions in Ontario this valuable timber has been almost exterminated. In this area, however, it was seen in numerous places, the most thriving trees having been seen along the river between Loon lake and Little Vermilion lake. On the whole, the forest growth in the Hunter island area is thriving, but there are some places near the boundary where serious fires have occurred. Along Birch and Carp lakes, and for a short distance along Emerald lake, fire has destroyed most of the forest, while the chief part of the region between Saganaga and Gunflint lakes has also been entirely denuded of its forest growth by fire. There is, however, an abundance of good timber for mining operations throughout the region.

IRON PYRITES DEPOSITS IN SOUTHEASTERN ONTARIO*

By P. E. HOPKINS

Introduction and History

In speaking of the economic geology of southeastern Ontario, W. G. Miller and C. W. Knight[1] say:

> There occurs in southeastern Ontario a variety of minerals and rocks of economic value, probably as great as in any district of like size on the North American continent. Some of these deposits, including marble and trap, are inexhaustible. Others, including talc and iron pyrites, have proved to be of considerable economic importance. From time to time, during the last 50 years, the following minerals and rocks have been mined or quarried with varying success: Gold, iron pyrites, zinc blende, copper pyrites, galena, mispickel, magnetite, hematite, talc, actinolite, mica, marble, ophicalcite, feldspar, fluorite, apatite, corundum, graphite and sodalite. All of the economic materials, with the exception of fluorite, appear to be of pre-Cambrian age. The fluorite veins penetrate the Ordovician (Black River) limestone.

Accompanying that report was an article by the writer on the Queensboro Pyrite Area which includes one of the two working pyrite properties in southeastern Ontario.

In the present paper will be given a brief description[2] of all the known pyrite deposits in the area which may at some time possess an economic value, with fuller descriptions of the two working mines—The Canadian Sulphur Ore Co.'s mine near Queensboro, and the Nichols Chemical Co.'s property at Sulphide.

The earliest mining of iron pyrites in Ontario was done in 1868 on the Billings property near Brockville. The mines were closed down in 1879 under the assumption that they were exhausted. Many other pyrite deposits have been worked for gold, iron or copper at some time. The steady pyrite industry of the Province began in 1900 when ore from the Bannockburn mine was produced. Mines in Hastings county have been steady producers since that time. An acid-making plant has been in operation at Sulphide since 1907 by the Nichols Chemical Co. for the treatment of its ore at Sulphide. The company also buys the ore mined from other properties in the neighbourhood. Another plant for treating custom ore is operated by the Grasselli Chemical Co. at Hamilton. These two plants treat the bulk of the eastern Ontario production, the remainder being shipped to the United States.

Recently a large percentage of the production has been coming from the Vermilion Lake deposits[3] in northwestern Ontario, the ore being shipped to United

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* Paper prepared for the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

[1] The Pre-Cambrian Geology of Southeastern Ontario, Report, Ont. Bur. Mines, Vol. 22, Pt. II, 1914.

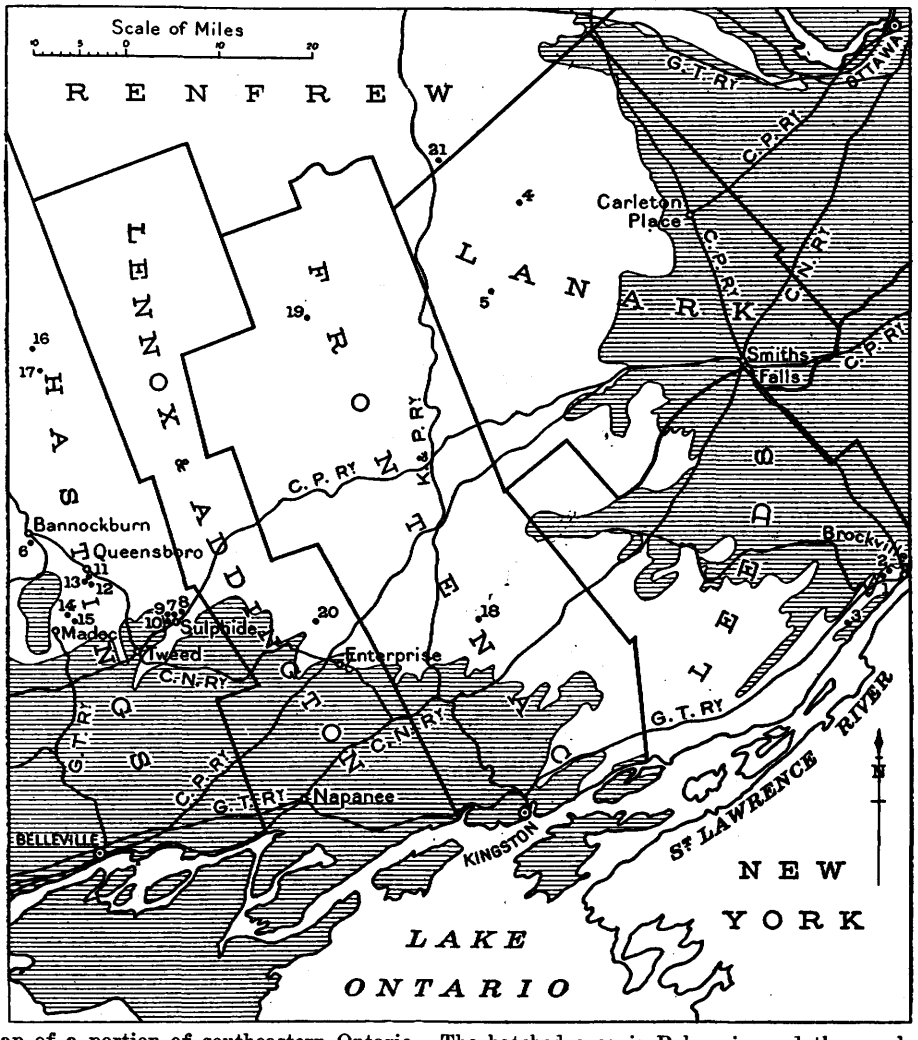
[2] The information regarding the various pyrite prospects in southeastern Ontario is summarized from E. L. Fraleck's comprehensive report on Iron Pyrites in Ontario, Report, Ont. Bur. Mines, Vol. 16, Pt. I, 1907, pp. 149-201.

[3] E. S. Moore: Vermilion Lake Pyrite Deposits, Report, Ont. Bur. Mines, Vol. 20, Pt. I (1911), pp. 199-213.

T. F. Sutherland: Northern Pyrites Company, Report, Ont. Bur. Mines, Vol. 24, Pt. I (1915), pp. 94-95.

States ports on the great lakes. Another property, the Goudreau lake deposits,[4] has been recently developed and expects to commence at once supplying large tonnages. The Helen mine,[5] operated by the Algoma Steel Corporation, produces some pyrite which is treated in its plant at Sault Ste. Marie.

The iron pyrites resources of Ontario are of considerable extent and value. In the last 15 years 538,755 tons, worth $1,438,122, have been produced, the



Map of a portion of southeastern Ontario. The hatched area is Paleozoic, and the numbers indicate the relative positions of the iron pyrites in the Pre-Cambrian.

greater part coming from southeastern Ontario. During the coming years there will undoubtedly be a steady increase in production. The war has had a stimulating effect on the demand of the United States for pyrite from Ontario.

[4] A. L. Parsons: Goudreau Pyrite Claims, Report, Ont. Bur. Mines, Vol. 24, Pt. I (1915), p. 211.

T. F. Sutherland: Madoc Mining Company, Report, Ont. Bur. Mines, Vol. 24, Pt. I (1915), p. 107.

[5] A. L. Parsons: Helen Mine, Report, Ont. Bur. Mines, Vol. 24, Pt. I (1915), pp. 202-205.

List Showing the Locations of Pyrite Deposits in Southeastern Ontario[6]

Brockville Section.

† 1. Brockville Chemical Co. (Billings property); lot 19, con. 2, Elizabethtown township.
† 2. Sloan prospect; lot 18, con. 2, Eliabethtown township.
3. Shipman prospect; about 6 miles west of the Billings (No. 1).

Lanark County.

† 4. McIlwraith mine; lot 5, con. 4, Darling township.
5. Ladore prospect; lot 19; con. 7, Dalhousie Township.

Hastings County.

‡† 6. Bannockburn (or Jarman) mine; lot 25, con. 6, Madoc township.
* 7. Hungerford mine (Nichols Chemical Co.); lot 23, con. 12, Hungerford township.
† 8. Canada mine (formerly Oliver Prospect); lot 26, con. 12, Hungerford township.
9. Hungerford Western Extension; parts of lots 21 and 22, con. 12, Hungerford township.
† 10. Ontario Sulphur Mines, Ltd.; northwest quarter of east half of lot 21, con. 12, Hungerford township.
† 11. Queensboro mine; lot 11, con. 11, Madoc township.
* 12. Canadian Sulphur Ore Co. (formerly Wellington prospect) N. ½ lot 9, con. 10, Madoc township.
† 13. Davis or Palmer prospect; lot 10, con. 10, Madoc township.
14. Farrell prospect; 2 miles northeast of Madoc village.
‡ 15. McKenty prospect; 2 miles east of Madoc village.
16. Little Salmon Lake deposit; lot 23, con. 7, Cashel township.
17. Gunter property; lot 23, con. 4, Cashel township.

Other Eastern Ontario Prospects.

18. Snooks prospect; lot 7, con. 14, Loughborough township, Frontenac Co.
19. Stalker prospect; lot 42, con. 6, Clarendon township, Frontenac Co.
20. Foley prospect; 5½ miles north of Enterprise Sta., Lennox, Addington Co.
21. Caldwell prospect; lot, 1, con.1, Blithfield township, Renfrew Co.

Brockville Section

The Brockville Chemical Co., No. 1,[7] began mining for pyrite on the Billings property in 1868. The ore occurred in a series of lenses conformable to the

* Mines now working (April, 1916) and shipping pyrites.
† Properties which have shipped pyrites.
‡ Properties which have shipped hematite or limonite.
[6] The number of each property refers to the corresponding number showing its position on the accompanying map.
[7] The numbers following mention of the pyrite properties refer to corresponding numbers showing their positions on the accompanying map.

lamination of a highly foliated pink granite gneiss. The lenses, which consist of pyrite and calcite in parallel lines, strike northeast and dip to the southeast. The richer shoots of ore were gouged out and no timbering was done. The main pit was sunk 250 ft. The ore was used for making acids in Brockville, the sulphuric and mixed acids being used at the fertilizer and dynamite works in and near Brockville. Operations of all kinds ceased in 1880. The evidence of the men who worked in the old pits is to the effect that they were never completely exhausted.

Sloan Prospect, No. 2.—A band of gossan strikes in a north-east direction across the property and dips to the southeast. The 20-ft. inclined shaft passes through 6 or 8 ft. of gossan. There is a width of 3 ft. of solid pyrites on the foot wall, the remainder of the shaft being in alternating bands of pyrite and crystallized calcite in equal amounts. Eighty tons of ore, running 40 per cent. sulphur, were shipped to Buffalo and Capelton.

The Buffalo-Brockville Mining Co. shipped a small tonnage from this lot during 1911 and 1912.

Shipman Prospect, No. 3.—The pyrite, which is much intermixed with pyrrhotite and country rock (gneiss), has been mined from an irregular pit 40 ft. long and 30 ft. wide.

Lanark County

McIlwraith Mine, No. 4.—The deposit, which is covered by 14 ft. of gossan, strikes north of east along a contact between diorite on the south and crystalline limestone on the north, and dips 60° to the south. It was first opened for gold. In 1899 and 1900 the shaft was deepened to 75 ft. and a 150-ft. tunnel run along the strike of the deposit, disclosing a length of over 90 ft. of clean high-grade pyrite inclosing lenses of quartz. A 12-ft. crosscut to the south did not pierce the width of the deposit. Three carloads of ore were shipped. Samples from the dump and tunnel, by E. L. Fraleck, gave 38.86 and 42.60 per cent. of sulphur respectively.

Ladore Prospect, No. 5.—A heavy fahlband strikes north of east along the contact of a coarse amphibolite and a fine-grained gray granite. The trenches and shallow pits expose a gossan in the form of bog iron ore, but pyrite in quantity was not located. The fahlband continues into the adjoining lot to the east along a contact of crystalline limestone and granite.

Bannockburn Mine, No. 6.—In 1898, the property was opened as an iron mine, 11 car loads of limonite, running about 38 per cent. in iron and low in sulphur, having been shipped. This ore was merely a gossan 8 to 15 ft. deep which capped iron pyrite deposits. The pyrites occurred as two lenses at right angles to each other, but conforming in strike and dip with the inclosing rock, a chloritic schist. Limestone covers the apex of the fold of the lenses. The south lens, which is 160 ft. long and 8 to 15 ft. wide, was mined to a depth of 275 ft. During the 6 years of operation about 580 tons of pyrite per month were shipped,

all of which went to the General Chemical Co. at Buffalo. The ore did not fall off either in grade or quantity with depth, but, owing to the hazard of open-pit mining, operations were abandoned in August, 1906.

Hungerford Mine, No. 7.—This property was opened 40 years ago as a gold property, and a smelter was erected to extract gold from the barren pyrite. The Nichols Chemical Co.[8] re-opened the mine in June, 1903. Owing to some difficulty about the title, the mine was closed down in August, 1904, but operations were resumed in August, 1905, and have since been continuous. Since 1907 acid works have been in operation for the treatment of company ores, and other ores in the vicinity.

Passing through this property, and extending beyond, is a large fahlband striking 25° north of east and traceable for 2 miles. Level farm land to the south is underlain by garnetiferous crystalline schist cut by massive diorite, into which, 500 yd. north of the deposits, has been intruded a pink hornblende granite that rises above the country in a series of rugged hills, locally called the Bald Mountains. The granite has protected the deposits from denudation. The deposits are strung along the contact of the diorite and the schist, the strike of lenses, contact, fahlband, and schist being identical.

The pyrite occurs in three parallel deposits striking with the schist and dipping 60° to the south. The middle one, which does not outcrop on the surface, lies 85 ft. from the south vein and 45 ft. from the north deposit. The north deposit, upon which most of the work has been done, varies in width from 6 to 22 ft. It has been exploited to a length of 620 ft. and to a depth of 575 ft., and the ore still continues. The length as indicated on the surface is about 500 ft. There are now two shafts on the property and about 3,500 ft. of drifting has been done on the orebodies on the six levels. During 1915 work was confined to stoping on the north vein and drifting on the south vein.

The ore is coarsely granular and makes a large percentage of fines. The main impurity is calcite, although there is also some quartz present. A small quantity of pyrrhotite occasionally occurs, mainly in the north lode next the foot wall. The average percentage of run of mine ore is about 35 per cent., the fines being much higher.

The acid works have been successfully operated since their completion in July, 1907, and machinery has been installed at various times to increase the capacity and to make new acids. At present sulphuric, hydrochloric, nitric and mixed acids are made by the contact process and shipped in the company's tank cars to various parts of Ontario and Quebec.

Electric power supplied by the Seymour Power and Electric Co. is used throughout the mine and acid works.

The Canada Mine, No. 8, which was formerly the Oliver prospect, adjoins the mine operated by the Nichols Copper Co. on the east, and is located on the same fahlband. The lode strikes east and west and dips 50° to the south. During part of 1907, the Canadian Pyrites Co. sank an inclined shaft on the deposit to a depth

[8] W. H. Nichols, President, 25 Broad St., New York.

of 110 ft. and did some drifting on the 85-ft. level, together with some diamond drilling. The deposit varies from 4 to 7 ft. in width. The ore on the dump is pyrite with a little pyrite and pyrrhotite, which will grade upward of 40 per cent. in sulphur.

The Hungerford Western Extension, No. 9, was fairly well prospected in 1906 by means of surface trenches at regular intervals along the strike of the fahlband. The western lens had been exploited by surface trenches to a length of 500 ft., exhibiting, near the line between the lots, a width varying from 16 to 18 ft. of ore, which will grade from 42 to 44 per cent. sulphur. The only impurity consists of small included lenses of calcite.

The eastern lenses are presumably continuations of the Hungerford mine orebodies.

A gossan 40 ft. wide occurs on the south end of the property, but not enough work has been done to determine the extent of the deposit.

The Ontario Sulphur Mines, Limited,[9] *No. 10,* commenced work in March, 1908, and continued until the end of 1911, save for 2 months in the summer of 1910. The pyrite deposit on which work has been done is located about ½ mile west of the Hungerford mine. It appears to be a lens pitching towards the southeast. A shaft has been sunk 300 ft., with 225 ft. of drifting on the 100-ft. level and 250-ft. on the 200-ft. level. According to A. W. G. Wilson[10] "The total shipments from the property up to the first of May, 1911, have been 4,821 long tons of ore averaging 36½ per cent. sulphur." In one place the deposit is 30 ft. wide.

The Sulphide Chemical Co. operated the property from the spring of 1913 until the following November, during which time the mine was dewatered and considerable ore was raised and shipped.[11] No work has been done since.

The Queensboro Mine (Blakely), No. 11, up to the autumn of 1906 shipped 65 carloads of pyrites running about 45 per cent. sulphur. Mine operations ceased in 1908. The pyrite occurs as a series of lenses up to 15 and 20 ft. wide along the contact of a garnetiferous schist (Grenville in age) and an instrusive pink felsite (post-Hastings in age). The ore is dense, the only impurity being thin veinlets of quartz. Cutting a pyrite lens is a small quartz vein containing copper pyrites and argentiferous jamesonite. In another place some zinc blende is interbanded with the pyrite. The main shaft is 135 ft. deep with about 175 ft. of drifting on the 50- and 85-ft. levels.

The Canadian Sulphur Ore Co.'s Pyrites Mine,[12] *No. 12,* was discovered in 1906 by Stephen Wellington while prospecting for iron. Under the gossan, merchantable iron pyrites was discovered, from which a car load of iron pyrites was shipped

[9] Formerly the Craig property.

[10] A. W. G. Wilson: Pyrites in Canada, Publication No. 167, Mines Branch, Ottawa (1912), p. 67.

[11] T. F. Sutherland: Report, Ont. Bur. Mines, Vol. 23, Pt. I, 1914, p. 174.

[12] Alex. Longwell, President, 410 Crown Office Building, Toronto. For a fuller description see The Queensboro Iron Pyrites Deposits, by P. E. Hopkins, Report, Ont. Bur. Mines, Vol. 22, Pt. II, 1913, pp. 89-104.

in 1908. Later, the Canadian Pyrites Syndicate bought the property, installed a small plant and shipped a few hundred tons of pyrite. In the spring of 1910 the property was handed over to the present company, which began shipping ore 3 months later, and has continued to the present. The mine is equipped to produce 100 tons of iron pyrites per day, yielding 40 per cent. of sulphur. Since Dec. 11, 1912, the mine has been run by electricity supplied by the Seymour Power Co. A branch line 2½ miles in length from the Bay of Quinte Railway near Queensboro to the mine was completed in 1913. The ore is shipped to the Nichols Chemical Co.'s acid plant at Sulphide, 11 miles southeast, and to the chemical companies at Hamilton and Detroit.

The pyrite is mined by underground and open-pit methods. The development work consists of three shafts and two open cuts, with some diamond-drill borings. Nos. 1 and 2 shafts, which are 75 and 100 ft. deep respectively, have been abandoned for some time. The work of late years has been confined to shaft No. 3, and the two open pits. The vertical shaft, No. 3, is 250 ft. deep with about 800 ft. of drifting on the 60-, 120-, and 200-ft. levels. The pyrite deposits are marked by gossan outcrops from 2 to 30 ft. in depth. Beneath are the pyrite deposits, which occur as lenses in contact with rusty schist to the south and white quartzite to the north (both Grenville in age) near an irregular post-Hastings intrusion of gray felsite. The strike of the deposits is slightly north of east, while the dip is almost vertical, inclining slightly to the south. Lenses vary in width up to 25 ft., but horses of country rock are frequently inclosed in the pyrites.

The ore is high grade, very little cobbing, if any, having to be done. Ores have been shipped running 40 to 48 per cent. sulphur.

The deposits are free from impurities such as arsenic, zinc, lead, copper and calcium. The pyrite burns satisfactorily, and is in good demand by sulphuric acid makers.

The Davis or Palmer Deposit, No. 13, is in the Grenville limestone. On the surface the pyrite is 2 ft. in width; 9 ft. down there is said to be a deposit 15 ft. wide. A few carloads of pyrites were shipped from a pit sunk on the property.

The Farrell Deposit, No. 14, lies in and conforms with the schist which strikes northwest. Test pits for a distance of 200 ft. show either gossan or pyrite. A shaft has been sunk to a depth of about 25 ft. A sample collected by E. L. Fraleck, representing an average of 75 per cent. of the dump (which consists of about 40 tons), yielded 40.64 per cent. of sulphur. The deposit maintains a uniform width of 5 ft., the only impurity being crystalline limestone.

The McKenty Prospect, No. 15, shipped hematite 40 years ago. A pit at one time 60 ft. deep has caved in. An examination of the cull dump reveals the fact that all large lumps of apparent hematite have, when broken, a core of pyrites. In E. L. Fraleck's opinion, this is one of many instances throughout eastern Ontario where hematite constitutes the gossan capping of a sulphide orebody.

The Little Salmon Lake Deposit, No. 16, occurs in a chlorite schist which strikes east and west, the main rock in the area being a white crystallized limestone, probably of Grenville age. A trench, 40 ft. long, uncovered pyrite 15 ft. in width. An average of 75 per cent. of the pyritiferous material yielded 38.83 per cent. of sulphur.

On the *Gunter Property, No. 17,* a shaft, 20 ft. deep, has been sunk on a deposit consisting of alternating bands of quartz and pyrite 5 ft. wide. A sample representing two-thirds of the dump yielded 39.50 per cent. of sulphur.

Snooks Prospect, No. 18.—A fahlband strikes northeast through a coarse, impure crystalline limestone, and can be traced across the adjoining lot 6 to Desert Lake. On the road allowance, 7 ft. of massive pyrite and 25 ft. of pyrite mixed with crystalline limestone were uncovered in obtaining material for the road.

On the *Stalker Prospect, No. 19,* is a well-defined fahlband, containing some hematite, and striking east and west. A small test pit has been sunk on a lens of pyrite which shows at that point a width of 6 ft.

The Foley Deposit, No. 20, occurs in an outlier of crystalline limestone surrounded on all sides at short distances by granite. The irregular deposit consists of small masses of pyrite and pyrrhotite in about equal proportions. The work consists of a pit, 80 ft. long, 40 ft. wide, and 10 to 15 ft. deep, sunk on pyrite and pyrrhotite in about equal proportions intermixed with pyroxene, calcite, mica and molybdenite.

The Caldwell Prospect,[13] *No. 21,* was opened in the fall of 1915 by Thomas B. Caldwell of Lanark. About 500 tons of ore have been mined, but the sulphur contents are not known.

[13] See fuller description of property under Mines of Ontario.

A STUDY OF CERTAIN MINERALS FROM COBALT, ONTARIO

By

H. V. ELLSWORTH

Introduction

In presenting this paper on certain mineral associations of Cobalt, the writer believes that, considering the importance of this famous mining region, no apology is necessary for the somewhat detailed descriptions in which he has been tempted to indulge.

The geology of the Cobalt area has received a great deal of attention, naturally, and has been admirably described by W. G. Miller and his associates in the reports of the Ontario Bureau of Mines. To them also is to be credited most of the published mineralogical data relating to Cobalt. In the Nineteenth Report of the Ontario Bureau of Mines, Part II, was included a descriptive list of the minerals which were known from Cobalt at that time, together with remarks on their mode of occurrence, and a table in which the probable order of deposition of the chief minerals was indicated. The order of deposition was also worked out by Campbell and Knight [1, 2] from observations on polished surfaces by the metallographic method.

Early in 1914, at the suggestion of T. L. Walker, Professor of Mineralogy at the University of Toronto, the writer undertook an investigation of breithauptite ore from the Hudson Bay mine. The results of this investigation seemed to have a bearing on the question of isomorphous inter-growths and led to a study of other mineral associations from Cobalt. Dr. Walker very kindly allowed the writer the use of the numerous specimens from Cobalt in the collection of the Royal Ontario Museum of Mineralogy, and in this way the work gradually broadened in scope.

In the following pages no attempt has been made to deal exhaustively with all the common minerals of Cobalt. Only such associations have been studied as were interesting because of the minerals hitherto unidentified from Cobalt, because of rarity or unusual crystallization, or because of a possible bearing on questions of isomorphism or paragenesis. These investigations have added the following to the list of minerals from Cobalt: Löllingite, rammelsbergite, chalcocite and symplesite.[3]

The objects of the investigation may thus be summarized as follows:

1. Descriptive: Identification and crystallographic study of special minerals, rare, or new to Cobalt. Identification in the case of the complex ores of Cobalt usually involves—2.

2. (*a*) Chemical analysis and separation experiments.
   (*b*) Microscopic study of polished surfaces.

3. Study of structures having a bearing on isomorphism.

4. Order of deposition or paragenesis, as shown by study of microscopic structures.

[1] Microscopic examination of the Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming by W. Campbell and C. W. Knight, Ec. Geol., Sept.-Oct., 1906.

[2] The Paragenesis of the Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming, Eng. and Min. Jr., June 9th, 1906.

[3] For list of Cobalt minerals see Report Ont. Bur. Mines, Vol. XIX, Pt. II, p. 9.

Methods of Microscopic Examination and Separation

The preparation of polished sections of minerals for examination by the metallographic method has been treated in detail by Campbell and Knight.[4]

The use of acids or other corrosive re-agents for developing the structure of polished surfaces of metals or minerals probably originated in the study of meteoric iron, the so-called Widmanstätten figures having been described in 1808. Outside of its application to meteoric iron, but little use seems to have been made of this method in mineralogy until Baumhauer[5] in 1886, applied it to the study of crystals of smaltite-chloanthite, with extremely interesting results. Vollhardt[6] analyzed the crystals which had been examined by Baumhauer before and after treatment with hydrochloric acid and potassium chlorate, and found that the residue left after the acid treatment was considerably richer in arsenic than the original material. From this result he deduced the presence of skutterudite ($CoAs_3$) in the smaltite-chloanthite crystals.

The writer has applied similar methods to the study of microscopic intergrowths from Cobalt. If a polished surface of a complex ore, containing two or more minerals closely intergrown, say smaltite and chloanthite, which are quite indistinguishable by ordinary means, be slightly etched with acid, the two minerals become easily distinguishable owing to the different effect of the acid upon them. If the etching be continued for a longer time one mineral will finally be corroded much deeper than the other, which stands in relief. It occurred to the writer that this method might be used to liberate minerals from the minute inclusions which are so characteristic of minerals from Cobalt, and it has, in fact, been used with success in some instances (see Breithauptite, page 210).

This difference in the action of an acid on the two minerals is not due entirely to the difference in the rate of solution of the individual minerals taken separately in acid of a given concentration. Gottschalk and Buehler[7] have shown that there is a difference of potential between different natural minerals and that two minerals in contact act as a battery in oxidation experiments, the current flowing from the mineral of higher potential, which is protected from the action of the oxidizing agent, while the mineral of lower potential dissolves more rapidly. There are also of course, instances in which one of the minerals reacts with the acid to form an insoluble coating which protects it while the other mineral is being dissolved away. Such coatings on a mineral of lower potential may, in certain instances, cause a reversal of the normal action, so that the mineral of higher potential actually dissolves more rapidly.[8]

Palmer and Bastin[9] have recently advocated the use of silver sulphate solution to separate arsenides from sulpharsenides and sulphides, the sulphate being chosen because of the bearing of their experiments on silver enrichment. The writer has

[4] Loc. cit.

[5] Ueber die Structur und die mikroskopische Beschaffenheit von Speiskobalt und Chloanthit, von H. Baumhauer, Zeitschrift für Krystallographie 12, 18, 1887.

[6] Versuche über Speiskobalt—von G. Vollhardt, Zeitschrift für Krystallographie 14, 407, 1888.

[7] Oxidation of Sulphides—V. H. Gottschalk and H. A. Buehler—Ec. Geol., Vol. VII, No. 1, Jan., 1912.

[8] Breithauptite, page 210.

[9] Tetranickel Triarsenide, Its Capacity as a Silver Precipitant, Chase Palmer, Econ. Geol., Vol. IX, No. 7, Oct., 1914.

used silver nitrate solution with equal success, and this has the advantage that it can be made up in much stronger solutions than the sulphate, which is not very soluble. With the nitrate solution results are obtained in less time and with much smaller volumes of solutions.

It should be remembered, however, that all the foregoing methods are capable under favourable conditions of producing only a pure residue. The less soluble mineral is not entirely unaffected by acids or silver solutions and will also enter into solution to a certain extent, so that the resultant solution contains the constituents of both minerals. The residue, after sufficiently long action should, theoretically, be pure.

Methods of Chemical Analysis

In general, the writer has used the methods recommended by Treadwell, 1914 edition. As different methods do not always yield identical results, those used here may be summarized as below:

Arsenic—Usually determined by the Pearce method.[10] After fusion of the ore with a mixture of sodium carbonate and nitrate, the alkali arsenate is leached out and converted into silver arsenate which is titrated with ammonium sulphocyanate solution. If the solution to be titrated contains the same amount of silver as was used for standardizing the sulphocyanate solution, the results are very accurate.

Antimony—Weighed as Sb_2S_3 after heating in a current of carbon dioxide.

Bismuth—Weighed as sulphide or oxide. Separated from lead by basic nitrate method.

Copper—By electrolysis of sulphuric acid solution.

Iron—Separated from nickel and cobalt by one or more precipitations as basic acetate followed by precipitation as hydroxide from nitric acid solution and weighing as Fe_2O_3. The writer has found that if the hydroxide be precipitated along with finely macerated ashless filter paper as recommended by Washington,[11] there is no danger of the formation of magnetite on ignition and the results agree exactly with permanganate titrations.

Lead—Weighed as sulphate in Gooch crucible.

Mercury—Weighed as sulphide after reprecipitation.

Nickel and Cobalt—Determined together by electrolysis of ammonium sulphate solution, using a revolving cathode. Nickel separated and weighed as nickeldimethylglyoxime, cobalt by difference. In precipitating small amounts of nickel from large quantities of cobalt, a very large excess of the rather expensive dimethylglyoxime is required, in fact more than enough to combine with all the cobalt must be used in order to precipitate all the nickel. In such cases, the writer first precipitates the cobalt as tripotassium cobaltic nitrite, the nickel in the acetic acid filtrate is then readily precipitated by a relatively small amount of dimethylglyoxime.

Silver—As chloride.

Sulphur—Usually by fusion of the ore with alkali carbonate and nitrate, or with a mixture of sodium carbonate and sodium peroxide. Weighed as barium sulphate. The writer has not obtained quite as concordant results with the sodium

[10] Low—Technical Methods of Ore Analysis.
[11] The Chemical Analysis of Rocks—H. S. Washington.

peroxide method as with the old Fresenius method. All analyses, except where otherwise noted, have been made in duplicate.

Native Silver

The silver of Cobalt, as is well known, usually contains both antimony and mercury. It has been generally supposed that the mercury is alloyed with the silver as amalgam, and that the antimony is in the form of dyscrasite.

It was thought that a microscopic examination of analyzed specimens might throw some light on the manner in which the antimony is combined with the silver.

Five specimens were analyzed as below:

	Ag	Sb	Hg	S	Co or Ni	As	Insol.	Total
I	93.61	5.89	.35	trace	trace	....	....	99.85
II	95.39	3.31	trace	.63	trace	....	.60	99.93
III	99.56	.17	trace	trace	....	trace	....	99.73
IV	92.60	6.59	.34	trace	trace	....	.22	99.75
V	90.54	.79	3.08	trace	trace	....	5.50	99.91

I. Slab silver—⅛ to ¼ inch thick, Buffalo mine.
II. do do Cobalt.
III. Thin leaf silver, Nova Scotia mine.
IV. Brittle moss-like silver, Cobalt.
V. Thin leaf silver from oxidized arsenate ore—Penn-Canadian mine. The 5.50 per cent. insoluble represents, chiefly, flakes of argentite which was separated approximately by using cold dilute nitric acid to dissolve the silver.

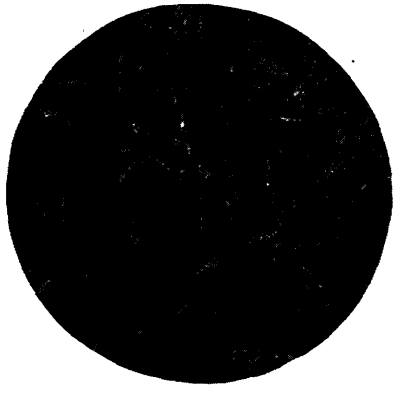


Fig. 1. Skeleton crystals of dyscrasite (?) in native silver, x 50.

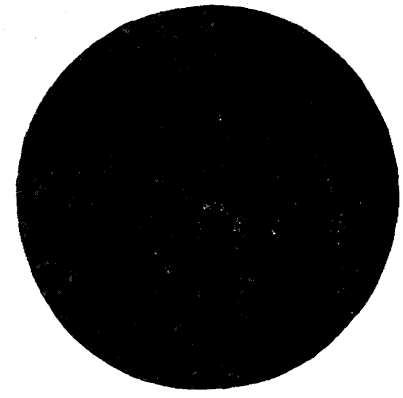


Fig. 2. Inclusions of argentite in native silver, x 50.

There is not enough antimony in any of these samples to form dyscrasite of theoretical composition and the question arises, does antimony combine chemically with silver in various proportions or is dyscrasite of theoretical composition alloyed or mixed with the silver. The stellate structure (Fig. 1) developed by etching a

surface of silver, specimen No. 1, would furnish a partial answer to this question if we admit that these radiating structures represent skeleton crystals of dyscrasite set in a ground-mass of silver, as seems probable from the antimony content of this sample (5.89 per cent. Sb.)

The specimen of silver, No. III, contained but very little antimony and mercury and developed no noteworthy structure on etching, only a few small inclusions being noted. The homogeneous character of the etched surface agrees with its chemical purity.

In the preparation of the samples special care was taken to exclude all visible foreign adhering material. In spite of this all showed traces of sulphur and one, No. II, showed a notable quantity. The sulphur appears to be due to the presence of argentite as minute inclusions in the silver. Microscopic examination of a sur-

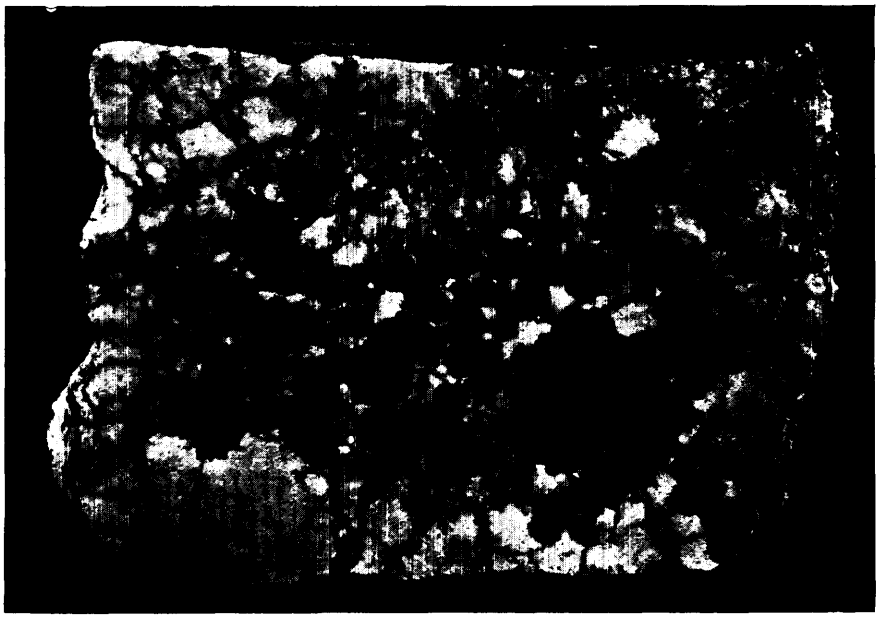


Fig. 3. Cross-section (natural size) of a rich silver vein, showing silver replacing arsenides and calcite.

face of No. II etched by nitric acid shows inclusions of a gray mineral which stands in relief and, therefore, must resist the acid better than silver (Fig. 2). This behaviour agrees with the known resistant character of argentite to cold dilute nitric acid.

There appears to be no relationship between the amounts of antimony and mercury in these analyses, but there can be no doubt whatever that the mercury is alloyed with the silver. Analyses of mineral samples in which silver is absent never show any trace of mercury and in this the writer's experience agrees with that of G. H. Clevenger of the Nipissing mill. Mr. Clevenger also shows that in the Cobalt ores he has analyzed the amount of mercury found is proportional to the silver content.[12]

[12] Note upon The Occurrence of Mercury on Cobalt Ores, by G. H. Clevenger, Econ. Geol., Vol. X, No. 8, December, 1915.

Paragenesis: Close examination of silver from Cobalt, in the writer's experience, always reveals the presence of more or less argentite, usually as thin amorphous coatings or scales attached to the surface of the silver. Thin coatings or patches of ruby silver are also common. Sometimes veinlets of argentite have a thin film of silver next the vein walls (Fig. 4). That the association of silver and argentite is very intimate is further shown by the presence of minute argentite inclusions in massive leaf silver (Fig. 2), as well as by the detection of traces of sulphur in several other samples. It is difficult to decide whether such structures are due to replacement or to more or less contemporaneous precipitation of both argentite and silver. At any rate the silver and argentite are later than the arsenide-sulpharsenide minerals since veinlets of silver may be seen cutting the latter (Fig. 3). Most of the silver fills in cleavage cracks and fractures or replaces calcite or arsenides. Fig. 3, a cross section of a typical very rich silver vein, illustrates well the replacement of arsenides by silver. In the picture both silver and

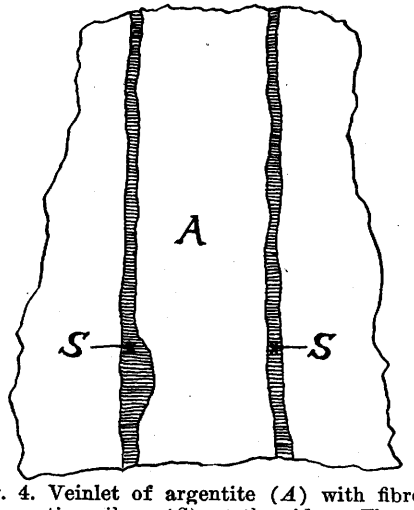


Fig. 4. Veinlet of argentite (*A*) with fibrous native silver (*S*) at the sides. The veinlet is about 2 mm. in width.

smaltite are dark, but the smaltite being harder has resisted buffing better and stands in relief. In the lower part of the picture native silver has almost completely replaced the arsenides, of which only a few fragments remain. In the upper part, the silver for the most part occupies the centre of the dendritic arsenide growths, and in some places can be seen connecting with veinlets in the calcite. There can be little doubt that in this case the arsenide minerals have been chiefly responsible for the precipitation of silver, and apparently the mineral which was originally in the centre of the dendritic growths was much more effective than the part that remains. This sort of structure might be expected to result from the reaction of cobalt-nickel arsenides on silver sulphate solution which has been demonstrated experimentally by Palmer and Bastin.[13] The writer's conception of the probable process is as follows:—The solutions from which the Cobalt ores were precipitated were at first very rich in arsenic, resulting in the precipitation of diarsenides, followed by arsenides. The arsenic content of the mother solution decreased as sul-

[13] Loc. cit.

phur became more prominent and sulpharsenides were also deposited. Finally the arsenic was practically all precipitated and the solution was essentially of a sulphate character. About this time came a slight movement, resulting in fracturing. The sulphate solution now carrying chiefly silver had an excellent opportunity to penetrate the fractured veins and come in contact with the arsenides which were dissolved while metallic silver and argentite were precipitated, resulting in replacement structures such as we have seen. No doubt the calcite also was concerned in the precipitation to an important degree. The dissolved arsenides were ultimately deposited elsewhere, resulting in structures in which the normal order of precipitation might appear to be reversed. Certain structures, the interpretation of which is very doubtful, do occur. Fig. 5 shows a beautiful dendritic growth of smaltite, with a very little niccolite, that is very suggestive of the tree-like crystallizations of silver. A few of these little tubes of smaltite are filled with silver, but calcite occupies the centre of most of them. There are also a few minute veinlets of native silver in the calcite.

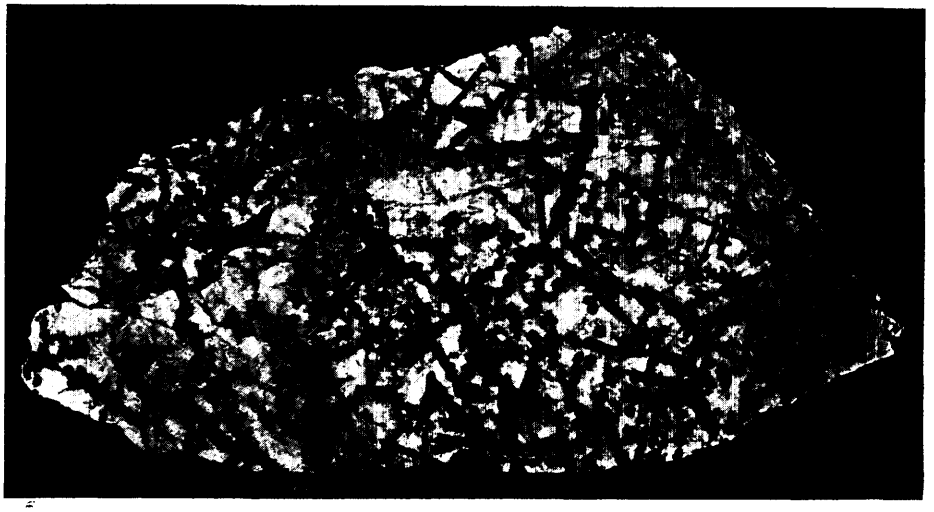


Fig. 5. Dendritic growths of smaltite, with native silver in calcite, reduced to three-quarters natural size.

Argentite Crystals, Casey-Cobalt Mine

A specimen from the Casey-Cobalt mine showed crystallized surfaces of argentite embedded in pure cleavable calcite. The argentite is closely associated with partially crystallized pyrite and these two minerals appear to have replaced or impregnated typical massive smaltite ore which makes up the rest of the specimen. In places, the argentite is intergrown with delicate filmy forms of native silver. On dissolving away the calcite with hydrochloric acid several well-developed, lustrous crystals of argentite were revealed. Examination of these crystals indicates that they occur in two distinct habits: 1. Simple, half-octahedrons attached vertically to the argentite mass, the plane of attachment corresponding to the direction of a cube face, and 2. Somewhat tabular forms which proved to be combinations of the rhombic dodecahedron, cube, icositetrahedron, trisoctahedron and tetrahexahedron (Fig. 6). These are also attached in a plane parallel to a cube face. A

single crystal of the latter type about 1 x 1.5 x 1.5 mm. in size was found to have good faces suitable for measuring. Using the two-circle goniometer good signals were obtained for most of the faces, the only ones which are at all doubtful being the two faces belonging to the tetrahexahedron (510). These faces are small and the signals are faint and hazy. They are certainly in a zone with cube and dodecahedral faces. The best readings on the horizontal circle gave values for ρ of 77° 50′ and 79° 10′ for the two faces. These faces have been interpreted as belonging to the form (510) of the tetrahexahedron, a form which has not been recorded by Goldschmidt or Hintze as having been hitherto observed on argentite but which does occur on fluorite.[14] The theoretical value of ρ for (510) is 78° 41′. Faces belonging to the following forms have been observed on the crystal: c (100); d (110); q (211); u (221); and ε (510).

The drawing (Fig. 6) is intended to represent this crystal in its natural proportions, and shows only the faces actually present.

This is probably the first measurable crystallized argentite recorded from Canada.

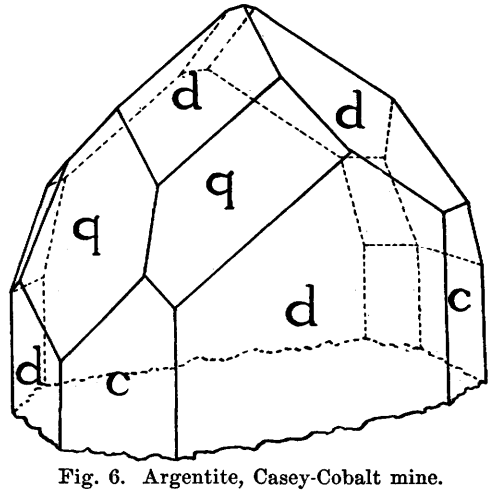


Fig. 6. Argentite, Casey-Cobalt mine.

Some of the partially crystallized argentite of this specimen was analyzed with the following results:

	Ag	S	Fe	Quartz	Sb (?)	Total
Per cent.	86.80	13.01	.08	.16	trace	100.05
Mol. Ratio	.8044	.4057	.0014	....	....	....
Argentite Ag_2S	.8044	.4029	....	....	....	....
Pyrite FeS_2	....	.0028	.0014	....	....	....

[14] Krystallographische Winkeltabellen—von. V. Goldschmidt.

The argentite is evidently very pure, the pyrite and quartz being merely accidental impurities.

A qualitative test of the pyrite shows that it also is practically pure if care be taken to obtain a sample free from adhering material.

One would be inclined to suspect from all the evidence that these two minerals were formed at a later period than the intimately mixed arsenide vein ore.

Argentite, O'Brien Mine

A specimen of argentite from the O'Brien mine attracted attention because of its peculiar iridescent tarnish resembling that of bornite, or perhaps more like the many-coloured tarnish which silver dishes assume after standing idle for some time in the laboratory. It was thought that this tarnish might indicate some variation in composition, and the mineral was accordingly analyzed. It proved to be ordinary argentite.

Ag	S	Sb or As	Cu	Co	Insol.	Total
86.91	12.86	trace	trace	trace	trace	99.77

This was the specimen from which crystals of polybasite were obtained. In a few places this argentite shows some evidence of a tendency to crystallize in forms which suggest rhombic rather than cubic symmetry. The argentite is associated with typical massive gray arsenide ore.

Galena Crystals, O'Brien Mine

Several large crystals of galena from the O'Brien mine are in the museum[14a] collection. They are rather remarkable because of their large size (up to 2.5 inches diameter), and because they are essentially octahedral in habit, cube faces when present being only slightly developed. The crystals are rough and have been more or less broken. Small grains and films of quartz can be seen along some of the broken cleavage surfaces, showing the same intimate association with quartz as was observed in the case of the very pure chalcocite from the Foster mine described on page 209.

Analysis of 1 gram samples failed to detect the presence of any impurity, except a small amount of iron.

	Per cent.			
Pb	86.56	÷ 207.10	=	.4182
Fe	.05	÷ 55.84	=	.0009
S	13.45	÷ 32.07	=	.4195
Total	100.06			

The purity of this galena is remarkable when one remembers the usual complex character of Cobalt ores. It is not unlikely that several of the very pure minerals which have been encountered, such as galena, chalcocite, argentite, pyrite and chalcopyrite, which are usually associated with quartz and very pure calcite, belong to a later period of formation than the typical complex vein ores and may have been formed by solution and reprecipitation after the main period of mineralizing activity was finished.

[14a] Royal Ontario Museum, Toronto.

Chalcocite, Foster Mine

The specimen consists chiefly of white calcite through which runs a veinlet of white granular quartz. The chalcocite occurs as small patches, usually not over a quarter of an inch in diameter, very intimately associated with the quartz, which is later than the calcite.

Analyses of half gram samples showed no impurities except minute quartz grains, as below:

	Actual	Theoretical
Cu	79.58 per cent.	79.84 per cent.
S	20.10 " "	20.16 " "
Quartz	.34	
	100.02	100.00

The mineral is included here because it has not previously been reported from Cobalt, and further because of its unusual purity and freedom from intergrowths of other minerals.

Chalcocite in a disseminated condition may possibly be a constituent of certain of the complex ores which carry copper, but tetrahedrite and chalcopyrite appear to be much more common.

The character of the gangue is noteworthy, the calcite being a white, very cleavable variety encountered before in examining crystallized argentite specimens, and which seems to be quite different from the ordinary vein calcite, which is usually hard and dolomitic. This calcite is very easily soluble and is practically pure calcium carbonate. Minerals with which it is associated are more apt to be crystallized or unusually pure. It probably belongs to a late stage of deposition or it may be of a secondary character.

Breithauptite Association, Hudson Bay Mine

Within recent years the rather rare mineral breithauptite has been found in the silver-bearing veins of several of the Cobalt mines. Some time ago the Department of Mineralogy, University of Toronto, purchased from the Hudson Bay Mines, Ltd., a quantity of vein material in which this mineral appeared to be prominent. Since no analysis of breithauptite from this locality has been published up to the present, the writer, at the suggestion of T. L. Walker, undertook an investigation of the above material.

The constituent minerals, as will be seen later, proved to be breithauptite, niccolite, cobaltite and native silver, with calcite as the gangue material. In a typical polished hand-specimen, the purplish copper-coloured breithauptite is seen as rounded arborescent patches varying usually from one eighth to one inch along the greatest diameter. These breithauptite areas are always completely enclosed by a relatively narrow band of pale, copper-coloured niccolite, which in turn is fringed by an equally narrow border of gray cobaltite. The layer of cobaltite is sometimes so thin as to be almost indistinguishable to the naked eye. The intervening spaces are filled with white calcite. Finally, in some of the specimens, veinlets of native silver penetrate all the minerals previously mentioned.

Etching Methods for Breithauptite

In order to study in more detail the structure of breithauptite and other associated minerals, and their relation to each other, various etching re-agents were applied to polished surfaces, with the following results:

I. Strong nitric acid momentarily applied produces a very beautiful effect by darkening the breithauptite while leaving the niccolite bright and unaffected. The cobaltite shows up with a brightness intermediate between breithauptite and niccolite. With a somewhat longer application the breithauptite is strongly attacked with the formation of a white coating of the oxides of antimony. The niccolite is relatively little attacked and if the coating of oxides be removed from the breithauptite, it seems to stand in higher relief than the latter. If, however, the action is allowed to continue until a thick coating of oxides forms on the breithauptite, a point is reached when the niccolite begins to be rapidly dissolved and finally is etched deeper than the breithauptite.

It appears that in the latter case the oxides of antimony form a coating over the breithauptite which tends to protect the mineral beneath from the action of the acid, but since no coating forms on the niccolite it continues to dissolve and finally is etched deeper than the breithauptite.

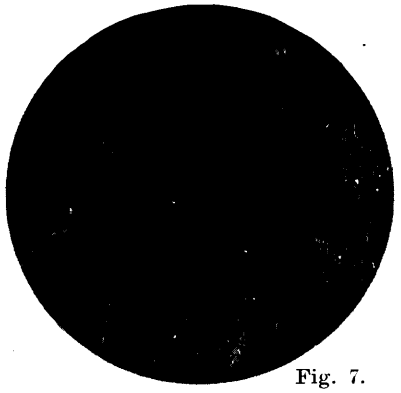


Fig. 7.

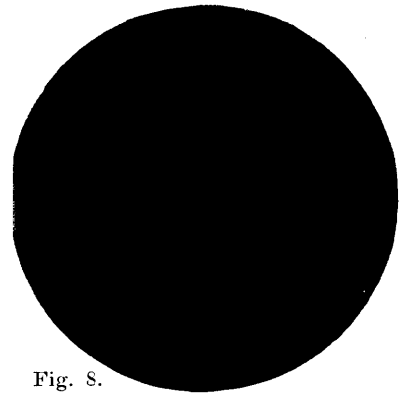


Fig. 8.

Fig. 7. The general structure of breithauptite as seen on a polished surface slightly etched with nitric acid. Magnification about 1½ diameters.

Fig. 8. Niccolite inclusions in bright relief in a ground mass of dark breithauptite. The darkest spots represent minute cavities in the breithauptite. (x 50).

The addition of tartaric acid to the nitric acid appears to prolong somewhat the time during which breithauptite is attacked with greater rapidity than niccolite. By repeatedly removing the specimen from the acid as soon as a moderately thick coating of oxides has formed and freeing the breithauptite surface of oxide by brushing and treatment with hydrofluoric acid, the breithauptite may be removed, without much affecting the niccolite. This observation suggested a method which is described later of removing breithauptite inclusions from niccolite.

II. Aqua regia attacks strongly both breithauptite and niccolite which dissolves to a clear solution. The cobaltite appears to be scarcely acted upon so long as the other minerals are present and hence stands in the highest relief after etching. By continuing this etching process until the breithauptite and niccolite have been entirely dissolved away, the cobaltite can thus be obtained as a residue free from both breithauptite and niccolite.

III. Hot dilute nitric acid (1-4) dissolves away the niccolite leaving breithauptite standing in relief and practically unaltered. The cobaltite is not perceptibly attacked but crumbles away as the supporting niccolite is dissolved and collects as a residue along with some breithauptite powder at the bottom of the dish. Since, as will be seen later, there are no cobaltite inclusions in the breithauptite itself we can thus eliminate both niccolite and cobaltite from the breithauptite.

Various other re-agents gave negative results or were so slow in action as to be valueless. Hydrochloric and sulphuric acids, strong or dilute, hot or cold, have but little effect. Hydrofluoric acid, though useless as an etching re-agent, proved useful in clearing away the oxides from etched surfaces.

Microstructure and Order of Deposition of the Breithauptite and Associated Minerals

The use of the etching methods outlined above produced surfaces in which the individual minerals by their differences in colour and relief could be very easily and clearly distinguished under the microscope or even with a hand lens.

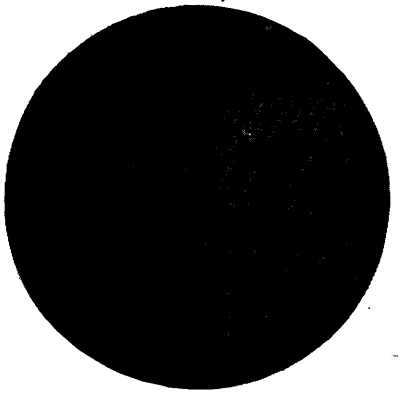


Fig. 9.

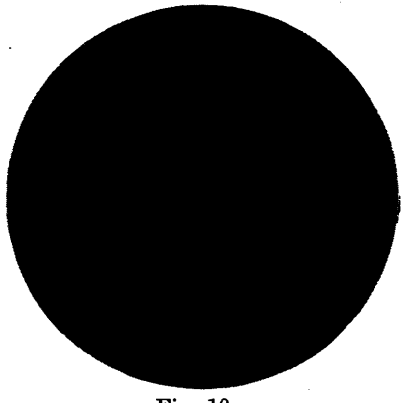


Fig. 10.

Fig. 9. The end of an arborescent area of breithauptite with characteristic niccolite inclusions is seen surrounded by a bright band of niccolite which on its outer edge is fringed by light gray cobaltite. Outside the cobaltite is a black band where calcite has been deeply etched, with two included dark gray areas at the top and bottom which represent calcite or perhaps a dolomitic calcite, since it is less deeply etched than that next the cobaltite. To the left is a small light gray area which represents the fringing cobaltite of another arborescent mass.

Fig. 10. Represents the same structure as Fig. 9, i.e., calcite filling the space between two closely arborescent masses, except that the envelope of niccolite is thicker and the cobaltite thinner than before. It should be noted that the vein-like appearance is very deceptive, suggesting that the breithauptite had been deposited massive, had subsequently been fractured, and in the cracks thus formed, niccolite, cobaltite and calcite had been deposited in order, as in a ribbon vein. This, however, is not the case. None of these minerals in reality penetrates the breithauptite, and fracturing did not occur until calcite had been deposited. The structure is due entirely to the closely arborescent form of the breithauptite, upon which the niccolite and cobaltite were precipitated. (x 70).

In all the specimens examined the same general relationship was found to hold; i.e., the aborescent breithauptite is entirely surrounded by a layer of niccolite which in turn bears a thin coating of cobaltite. On dissolving out the calcite which fills the intervening spaces, the outer surface of the cobaltite next the calcite is often seen to be crystallized in the form of brilliant cubes. In the specimens richest in breithauptite the layer of niccolite and cobaltite are relatively very narrow, typically

not over one millimetre thick and often very much less, with arborescent breithauptite closely set and with little intervening calcite. Other specimens show relatively small patches of breithauptite surrounded by a ground mass of niccolite as though the breithauptite had been the nuclei around which comparatively large quantities of niccolite had precipitated. The specimens richest in cobaltite are characterized generally by rather small and scattered breithauptite areas with calcite more prominent. When native silver occurs it appears to fill cracks which penetrate all the minerals just mentioned.

Micro-structure of Breithauptite.—After etching with nitric acid the breithauptite appears as a dark porous massive surface containing numerous minute irregular inclusions of niccolite which stand in bright relief (Fig. 8). The breithauptite areas with their coating of niccolite and cobaltite and the calcite filling in the spaces between this arborescent complex may be seen in Figures 9, 10 and 11. No inclusions of any mineral other than niccolite were observed in the breithauptite,

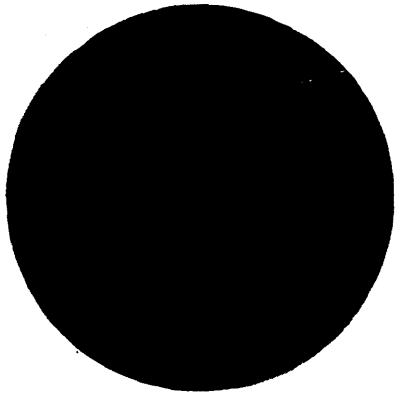


Fig. 11. The same structure as shown in Fig. 9. A few dark breithauptite inclusions in the niccolite may be noted. As before, the black vein-like band represents deeply etched calcite. (x 50).

which with this exception appears to be quite uniform and pure. Neither breithauptite nor niccolite exhibit any evidence of crystal form or structure. These structures suggest a simultaneous precipitation of breithauptite and minor quantities of niccolite as the first of the minerals to be deposited.

Micro-structure of the Niccolite.—The niccolite, which occurs as a narrow coating on the breithauptite appears to be quite pure, and has the closely granular appearance typical of a pure metal or mineral. In the more massive areas it contains inclusions of breithauptite which here also tend to be arborescent and appear to have been the nuclei around which the niccolite was deposited (Fig. 12). It also contains inclusions of cobaltite (Fig. 13). From the structures seen in Figs. 9, 10 and 11 the niccolite seems to have come down in maximum quantity after the breithauptite had been entirely precipitated.

Micro-structure of the Cobaltite.—This mineral occurs as a thin coating on the niccolite (Figs. 9, 10 and 11). It appears to have an extremely fine granular structure and may at times contain a few small inclusions of niccolite. The surface next the calcite is sometimes crystallized in cubes as previously mentioned. From

its position as the outer layer of the arborescent masses it appears to be the last formed of the nickel-cobalt minerals.

Calcite fills in the spaces between the arborescent masses of breithauptite, niccolite and cobaltite, and hence is next in order of deposition after cobaltite. It appears to be the ordinary white variety with good cleavage in places and effervesces readily with cold dilute hydrochloric acid. Some portions are more dolomitic, however, as may be seen by reference to Fig. 9, where the calcite next the cobaltite has been etched deeper than the central parts. A few small grains of quartz occur with the calcite. Minute slender prisms of ruby silver were seen embedded in the calcite between the nickel-cobalt minerals. They were too small for measurement or analysis.

Veinlets of native silver fill irregular cracks that at times penetrate all the nickel-cobalt minerals as well as the calcite (Figs. 14, 15). Occasionally silver may be seen filling cleavage cracks in the calcite, a good example of which is shown in

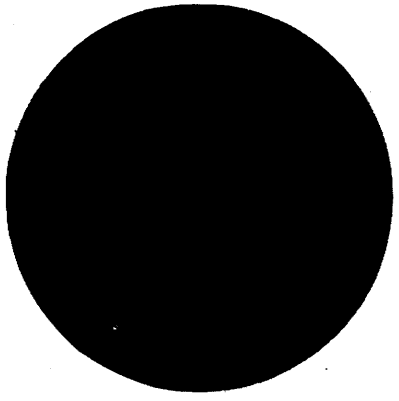


Fig. 12.

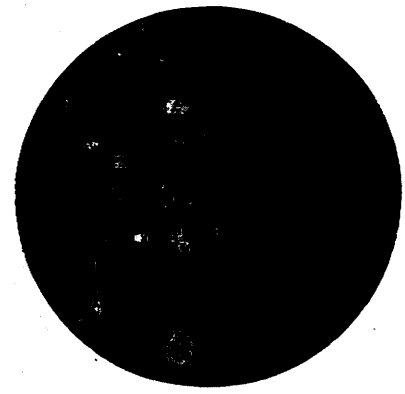


Fig. 13.

Fig. 12. Two skeleton-like areas of light-coloured breithauptite set in a dark ground mass of porous niccolite. (x 50).

Fig. 13. Cubes of cobaltite in bright relief included in a ground mass of dark, somewhat porous niccolite. The darkest spots represent cavities in the niccolite. (x 50).

Fig. 16. These structures would seem to indicate that subsequent to the deposition of calcite there was a slight movement which caused more or less fracturing in all the minerals and developed cleavage cracks in the calcite. In these fractures and cleavage cracks the native silver was deposited.

Summary: From the structural evidence, it appears that breithauptite was the first mineral deposited accompanied by relatively small amounts of niccolite as microscopic included grains. After the precipitation of breithauptite had ceased the niccolite continued to come down and formed a thin layer over the arborescent breithauptite. On the niccolite was deposited a thin coating of cobaltite with the outer surfaces partly crystallized. Thus both niccolite and cobaltite were moulded upon the breithauptite. The deposition of the nickel-cobalt minerals then ceased and the spaces between the arborescent masses were filled with calcite. Then came a period of movement with a slight fracturing of the minerals, and finally native silver was deposited in the cracks thus formed.

The order of succession of the minerals studied would seem to indicate broadly three periods of deposition as follows:—

I. Period of deposition of nickel and cobalt minerals, the nickel minerals being first.
   1. Breithauptite with minor amounts of niccolite as inclusions.
   2. Niccolite.
   3. Cobaltite.

II. Calcite with perhaps a little ruby silver. Period of slight movement and fracturing.

III. Native silver.

Separation of the Minerals for Analysis

It became evident from microscopic examinations after etching that the nickel and cobalt minerals were so intimately associated as to render of doubtful value any analysis of merely hand-selected material. The separation of the minute niccolite inclusions from the breithauptite and of the breithauptite and cobaltite inclu-

Fig. 14.

Fig. 15.

Fig. 14. A veinlet of scratched native silver is shown cutting through two masses of the nickel-cobalt minerals and the calcite which fills the space between them, proving conclusively that it was the last mineral deposited. The light granular mineral in high relief is niccolite, the dark spots intermingled with the niccolite represent breithauptite. Cobaltite, as usual, fringes the niccolite as the fine-grained, light gray mineral next the black calcite. Some of the best examples of this structure were too large to photograph. (x 60).

Fig. 15. Another example of a silver veinlet cutting the light-coloured nickel cobalt minerals at the top and bottom, and dark calcite to the right and left. (x 60).

sions from the niccolite was manifestly impossible by any mechanical means. In this connection the following paragraph from Campbell and Knight is here particularly applicable:

> From the above (a photomicrograph showing microscopic inclusions in smaltite) it is seen how an apparently homogeneous mineral varies from the centre to the outside and also contains other minerals as impurities so finely distributed through it that complete mechanical separation would be impossible. We can also understand how in this way analyses would vary as recorded by Dana.[15]

An attempted separation by means of the electro-magnetic concentrator proved unsuccessful, and since mechanical separation was out of the question, it occurred

[15] Microscopic examinations of the Cobalt-Nickel arsenides and Silver deposits of Temiskaming—Economic Geology, September-October, 1906.

to the writer that a separation might be effected by the prolonged application of the etching methods previously outlined.

The behaviour of a mineral with acids when intimately associated with another mineral is sometimes not the same as when it alone is treated under similar conditions with the same acids. An instance of this is recorded by V. Goldschmidt and A. L. Parsons as follows:

> By treatment with dilute hydrochloric acid the calcite can be dissolved out without the goethite being in the least attacked, so long as the least trace of the calcite is present.[16]

This fact was also noticed by the writer in the case of the association of minerals under discussion. It was found, for example, that aqua regia rapidly dissolves breithauptite and niccolite, leaving the cobaltite apparently quite unattacked so long as breithauptite or niccolite is present, but as soon as the two former minerals have disappeared, the cobaltite is at once vigorously attacked and quickly dissolved. Thus the cobaltite can be completely separated from the breithauptite and niccolite.

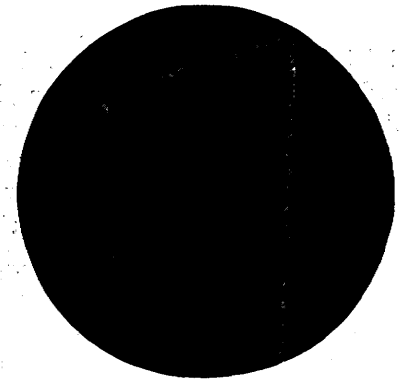


Fig. 16. White native silver filling cleavage cracks in dark calcite. This structure terminates an irregular, much thicker vein, the end of which is seen at the lower right-hand corner.

Similarly, though both niccolite and breithauptite alone are violently attacked by concentrated nitric acid, yet when the two minerals together are acted on by this acid the niccolite is relatively little attacked so long as a clean surface of breithauptite is present. Under the conditions described under etching methods, this process thus affords a means of freeing niccolite of breithauptite inclusions but not of cobaltite, which resists nitric acid so long as breithauptite or niccolite is present. Cobaltite, when alone, however, is readily attacked and quickly dissolved by nitric acid.

Finally, hot dilute nitric acid (1-4) dissolves away the niccolite leaving breithauptite practically unaltered, so that in this way we can free the breithauptite from niccolite inclusions. Here, again, when the niccolite has almost or quite disappeared, the solubility of the breithauptite in the dilute nitric acid is apparently much increased.

The details of the application of these methods are described below.

[16] Über Goethit von V. Goldschmidt und A. L. Parsons—Zeitschrift für Krystallographie usw. XLVII. Band, 3 Heft.

Isolation of Breithauptite.—A specimen containing as little niccolite and cobaltite as possible and with relatively large and pure-looking areas of breithauptite was selected and sawn into slices about an eighth of an inch thick. These slices were then treated with hot dilute nitric acid (1-4) until the outside coating of niccolite had been dissolved away and the slices presented the appearance of arborescent skeletons of breithauptite. The cobaltite falls off as the supporting niccolite is dissolved, leaving the breithauptite free of all impurities except the microscopic niccolite inclusions still contained in the interior. These thin branching pieces of breithauptite were then broken up by hand and inspected for freedom from niccolite and cobaltite. In this way about seven grams of breithauptite were obtained which apparently were entirely free of cobaltite and free of all but microscopic inclusions of niccolite. The specific gravity of this sample was 8.14 at 20° C. The arsenic content was 5.83 per cent. These selected pieces were then broken to 100 mesh and again treated with dilute nitric acid until the breithauptite began to be noticeably attacked as shown by the formation of the white antimony oxide. The breithauptite in the form of fine grains of size considerably less than 100 mesh was then rinsed and treated with dilute hydrofluoric acid to clear off any oxidised material, rinsed again and dried with alcohol at 120° C. Under the microscope the rounded grains thus obtained appeared to be of good colour, lustrous and apparently unchanged by the acid, though the sample in bulk was slightly darker than the original massive material. No cobaltite was visible. The specific gravity of the sample of about three grams was 8.23 at 20° C, but allowance must be made for the finely divided condition of the sample which results in slightly too high a figure for the specific gravity.[17] This material was then analyzed with the following results:—

Ni	Co	Fe	Sb	As	S	Total
32.09	.59	.04	66.62	.58	nil	99.92

It may be noted that the amount of nickel found is relatively a little low. This may be due to loss in analysis or to a slight surface oxidation of the breithauptite by the acid by which the bases are subtracted leaving a film of antimony oxide on the grains. As to the chemical constitution of the breithauptite, it seems probable that the cobalt and iron present replace some of the nickel since there is no microscopic evidence of the presence of cobaltite, while the absence of sulphur is a further confirmation. As to what extent arsenic actually replaces antimony, it is difficult to decide. The remainder of the material, after the analysis was subjected to further treatment with dilute nitric acid, was analyzed and the arsenic re-determined and found to be 0.47 per cent., which indicates that some niccolite was still present. This exhausted the supply of material. It is probable, however, that isomorphous arsenic, if present, amounts to less than 0.47 per cent.

The above analysis shows that the breithauptite is individually quite pure; in fact, this is nearer a theoretical analysis than any given by Hintze or Dana. It also

[17] Day, Allen and Iddings—The Isomorphism and Thermal Properties of the Feldspars. Pages 56, 57.

demonstrates that the chemical separation was in a large measure successful though for lack of material the niccolite was probably not entirely eliminated.

The following results were obtained on material from the same specimen:—

1. Hand-picked grains between 20 and 40 mesh selected for purity:—arsenic content = 11.23 per cent.

2. Grains with outer coating of niccolite removed by dilute nitric acid but still containing microscopic niccolite inclusions in the interior:—arsenic content = 5.83 per cent.

3. Material reduced to 100 mesh and again treated with dilute nitric acid:—arsenic content = 0.47 per cent.

The fact that this breithauptite though apparently pure and homogeneous to the naked eye contains nevertheless over five per cent. of arsenic, as microscopic niccolite inclusions is evidence of the importance of a microscopic examination of minerals which are to be submitted to analysis, since it may settle the question as to whether the presence of certain elements is due to isomorphous replacements or to admixture with another mineral in which they are contained.

Isolation of Niccolite.—One of the largest, purest specimens containing relatively little breithauptite was sawn into slices about one sixteenth of an inch thick which were treated with concentrated nitric acid containing tartaric acid as previously described under etching methods. When all the breithauptite that could be reached by the acid had been removed, the pieces were broken successively to 20, 40, 60, 80 and 100 mesh and retreated after each sizing. In this way it was hoped that the breithauptite inclusions would be eliminated. The sample was finally treated with hydrofluoric acid to clear off oxides, rinsed and dried at 120° C. Under the microscope the grains appeared bright, clean and of good colour. The sample, however, still contained brilliant cubes of cobaltite which apparently had scarcely been effected by the acid.

Considerable experimenting had previously been done with a view to finding some re-agent which would dissolve the cobaltite without affecting the niccolite or breithauptite, but all these attempts proved unsuccessful. There is, therefore, no means of determining absolutely whether any of the nickel is replaced by cobalt in this niccolite. Analysis of the sample thus prepared yielded the following results:—

Ni	Co	Fe	As	Sb	S	Total
40.64	2.04	trace	50.78	4.95	1.47	99.88

Specific gravity of the sample at 20° C = 7.66.

The remainder of the sample after analysis was re-treated with acid and the final determination yielded 3.81 per cent, of antimony. From the result it would appear that the material analyzed still contained breithauptite, and the amount of possible replacing antimony is thus reduced to less than 3,81 per cent., though it seems likely that most of this represents breithauptite.

Since sulphur is present in excess of the amount required to combine with the cobalt to form cobaltite, we must assume the presence of isomorphous sulphur to the extent of 0.37 per cent., if we consider all the cobalt to exist as cobaltite of theoretical composition.

Here again in the case of niccolite is demonstrated the usefulness of a microscopic examination. We know definitely that any antimony in excess of 3.81 per cent. exists as breithauptite, and also that a large proportion of the cobalt is present in the form of cobaltite.

A determination of antimony is 20-40 mesh grains of niccolite from the same specimen, carefully selected by hand and in which no breithauptite was visible to the naked eye yielded 17.76 per cent. Had there been no microscopic examination this would probably have been reported as an arite with the above percentage of antimony replacing arsenic. Thus it is possible that certain so-called arites may be in reality relatively pure niccolite containing minute inclusions of breithauptite. Similarly a sample of breithauptite containing a high percentage of very minute niccolite inclusions might also be reported as arite, though the enclosing breithauptite itself might be almost of theoretical purity. In this way an entirely fictitious series of arites containing any proportion of arsenic and antimony might be obtained.

Isolation of Cobaltite.—Examination of the hand specimens showed that those in which the calcite gangue was relatively prominent with the breithauptite as rather small and scattered areas, were richest in cobaltite. Such a specimen was selected, reduced to 40 mesh and after the calcite had been dissolved out was treated with aqua regia. In this way the breithauptite and niccolite were dissolved away, leaving the cobaltite as a relatively very small amount of finely divided residue. As previously noted, the cobaltite is apparently scarcely acted on until the breithauptite and niccolite have disappeared. It was found that the cobalt residue contained no nickel, so that the very delicate dimethylglyoxime test could be used to ascertain when all breithauptite and niccolite had been removed. When fresh quantities of the aqua regia solvent, therefore, no longer reacted for nickel, the separation was complete and the residue was washed, dried and examined under the microscope. The whole amount readily passed the 100 mesh. It was seen to consist partly of material without crystal form, derived, no doubt, from the layer coating the niccolite, and partly of very perfect cubic crystals which still retained their sharp edges and corners and brilliant metallic lustre. Accompanying the cobaltite were grains of yellow, rose-coloured, white and colourless quartz derived from the calcite gangue, and a few minute particles of silver. In order to get rid of the quartz grains the residue was treated with hydrofluoric acid until they were all dissolved. This was followed by dilute nitric acid to dissolve the silver.

In this way about three grams of apparently pure and in part crystallized material were obtained. The sample had a specific gravity of 6.35 at 20° C.

Analysis of this material dried at 120° C. yielded the following result:—

CO	Ni	Fe	As	S	Ag	Total
34.83	nil	89·	46.97	.04	17.48	99.95

From the above analysis and its cubic crystallization the mineral appears to be cobaltite, which has the theoretical composition: Co. 35.5, As. 35.2, and S. 19.3 per cent. The small amount of silver present was doubtless due to the escape of particles of native silver not affected by the nitric acid.

It will be noted that the arsenic is in excess of the theoretical percentage, while the sulphur falls below. This may result from replacement of sulphur by arsenic or may be due to the presence of small quantities of skutterudite, $CoAs_3$. The somewhat high specific gravity of the sample rather favours the latter explanation. To settle this point absolutely would require a relatively large sample of the cobaltite residue, which would necessitate the destruction of several pounds of the original specimens. There would then still remain the difficult problem of isolating the supposed skutterudite from the cobaltite.

However, the fact remains that cobaltite is, in any case the important constituent of the material analyzed. Further, it is remarkably pure as compared with most of the analyses given by Hintze and Dana. Iron is present in very small amount, and the entire absence of nickel as shown by the dimethylglyoxime test on one gram of material is especially noteworthy, since from its close association with niccolite and breithauptite it might be expected to contain nickel replacing cobalt.

General Conclusions Regarding Breithauptite and Associated Minerals

The methods of chemical separation adopted as a result of observation of the relative etching effects of various acids have proven successful except in the case of cobaltite inclusions in niccolite.

That the three minerals, breithauptite, niccolite and cobaltite, though so very closely associated as to suggest simultaneous precipitation, especially in the case of breithauptite and niccolite (Fig. 8), nevertheless individually possess almost their respective theoretical compositions with but very little possible replacement by isomorphous elements, would indicate the possibility of the wide variation in some mineral analyses being due more to admixture with other minerals than to actual replacement with isomorphous elements.

Smaltite and Chloanthite Crystals, Foster Mine

A specimen of what appeared to be very pure smaltite from the Foster mine showed good crystals embedded in a hard dolomitic gangue. The crystals are slightly distorted cubes with small octahedral and still smaller rhombic dodecahedral faces. Some of the cubes reach a size of 5 millimetres.

It was thought that it would be interesting to see if these crystals were intergrowths like those described by Baumhauer, and analyzed by Vollhardt. One of the cubes was cut through the centre and polished parallel to a cubic face. After etching with acid it was seen to be made up of two different materials which were intergrown as shown in Fig. 17. On further etching at least two other components could be recognized but these were present only in very small amount. The massive part of the specimen was also etched and showed the same two prominent materials (Fig. 18) together with small quantities of others not identified. On prolonged etching the inner part of the growths was corroded deeper than the outer later part and relatively much nickel passed into solution, so that the central areas are

probably essentially chloanthite. There are also extremely minute inclusions in the chloanthite which can be seen only with a high power.

A single analysis was made on crystals with the following results:

Co	Ni	Fe	Cu	As	S	Total
13.81	11.35	1.21	.96	71.61	.75	99.69

A sample of the more massive, but partially crystallized material was prepared in order to try some separation experiments. This sample on analysis yielded the following results:

Co	Ni	Fe	Cu	As	S	Total
12.16	14.14	2.10	.40	66.87	4.13	99.80

Co: Ni: Fe = 5.79 : 6.73 : 1
Theoretical composition of smaltite—Co 28.12 and As 71.88 per cent.
" " of chloanthite—Ni 28.12 and As 71.88 per cent.

Fig. 17.

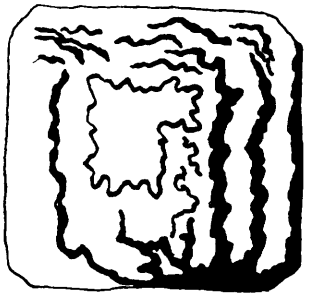


Fig. 18.

Fig. 17. Intergrowth of smaltite and chloanthite in a crystal about 2 millimetres in diameter (x 50).

Fig. 18. Sketch showing major features of smaltite-cloanthite intergrowth in a crystal 2 mm. in diameter as seen under the low power.

It is evident that both the crystals and the more massive material consist of about equal parts of smaltite and chloanthite.

A sample after prolonged treatment with hydrochloric acid and potassium chlorate, yielded a residue from which the following amounts were obtained:—

Co = .0868 g, Ni = .0064 g, Fe = .0098 g or

Co : Ni : Fe = 8.857 : 0.65 : 1

It is evident that this residue was nearly pure smaltite.

Another sample was agitated with successive quantities of silver nitrate solution and the solutions thus obtained were analyzed.

First solution yielded Co = .0068 g, Ni = .0393 g, Fe = .0018 g or

Co: Ni: Fe = 3.77: 21.83: 1

Second solution yielded Co = .0409 g, Ni = .0222 g, Fe = .0080 or
Co: Ni: Fe = 5.11: 2.77: 1
Third solution yielded Co = .0686 g, Ni = .0173 g, Fe = .0113 g or
Co : Ni : Fe = 6.07 : 1.53 : 1

These experiments serve to show that silver nitrate solution acts more readily on chloanthite than on smaltite, but as a separation method the large amount of silver precipitated is a disadvantage as it tends to retard the action of the solution, which becomes very slow as the amount of silver increases.

The results obtained seem to indicate that a smaltite residue containing little or no nickel might be obtained by sufficiently prolonged application of suitable separation methods.

Paragenesis—Considering first of all, the intergrowths which occur as good crystals, it seems probable that the crystals grew continuously from a mother solution which contained the elements of both smaltite and chloanthite, and that both these minerals were being precipitated as the crystals grew. The absence of definite concentric or zonal structure renders it unnecessary to suppose that the crystals were formed by overgrowth due to sharp changes in the cobalt and nickel content of the solution. A study of the massive part, however, seems to indicate that chloanthite was formed in greatest quantity during the early stages. The chloanthite areas are not pure but contain minute inclusions which are probably smaltite, and are bordered by smaltite. Apparently chloanthite was predominantly precipitated at first, and smaltite slightly later, but the two periods overlap.

Summary—The crystals examined are not homogeneous mixed crystals of cobalt-nickel diarsenide, but are intergrowths of about equal parts of smaltite and chloanthite, which appear to have been precipitated together. Chloanthite is doubtless much more common at Cobalt than has been supposed as a constituent of massive smaltite ore, and in the aggregate may be responsible for a greater part of the nickel content of Cobalt ores than the more conspicuous niccolite.

Cobaltite Crystals, Columbus Claim

The crystals which have been found at this mine are probably not surpassed in perfection of development by those of any other known locality. They are essentially octahedral in habit, with relatively small cube faces. A small percentage have the cube and octahedron about equally developed but in the great majority the octahedron predominates.

One of the crystals—an octahedron with small cube faces—measures 7 mm. between cube faces.

These crystals have been analyzed by J. S. De Lury [18] and found to contain notable amounts of iron and nickel. Remembering the slight solubility of cobaltite relative to the more common arsenides, which was displayed in the separation of minute cobaltite crystals from niccolite and breithauptite and also bearing in mind the very small capacity of this mineral for precipitating silver from silver sulphate solutions, noted by Palmer and Bastin,[19] the writer decided to subject

[18] Cobaltite Occurring in Northern Ontario, Canada, by Justin S. De Lury—American Journal of Science, Vol. XXI, April, 1906.

[19] Metallic Minerals as precipitants of silver and gold, Economic Geology, Vol. 8, No. 2, March, 1913.

samples of this cobaltite to the action of such re-agents as might be expected to act more rapidly on any iron or nickel minerals that may be present as microscopic inclusions.

A preliminary microscopic study of etched surfaces of these crystals revealed numerous inclusions which it was thought might be sufficient in amount to account for the iron and nickel found in the analysis. For instance, a very perfect crystal which showed no evidence whatever of inclusions, externally, was cut through the centre parallel to a cubic face. In this case inclusions of at least two different minerals were observed. On being strongly etched with concentrated hydrochloric acid and potassium chlorate, one kind of inclusion is strongly attacked while another kind appears to be even more resistant than the cobaltite itself (Fig. 19). Some of the

Fig. 19. Inclusions of gersdorffite (?), light, in relief, in ground mass of a cobaltite crystal. Another sort of inclusion has been deeply corroded and is represented by the black line crossing the picture.

inclusions occur as wandering lines which can scarcely be fractures, since in some cases, they have a roughly concentric arrangement. On the other hand, unmistakable mineral-filled fractures are present in some of the other crystals. The inclusions that appear to be more resistant than the cobaltite are scattered throughout the cobaltite groundmass in irregular grains which remain bright and unattacked, even when the cobaltite has been roughened and the more soluble inclusions deeply corroded by the strong acid.

The structure suggests that most of the inclusions were formed at the same time as the cobaltite and that there is good ground for believing that the iron and nickel found by analysis are due to mineral inclusions rather than to isomorphous replacement of cobalt by nickel and iron.

A sample of about 5 or 6 grams of crystals, free from adhering matter was selected, ground to 200 mesh and analyzed, with results as in No. 1.

	Co	Ni	Fe	As	S	Total
I	28.11	3.07	4.76	44.61	19.57	100.12
II	28.28	3.12	4.40	44.82	19.20	99.82
III	28.64	3.06	4.11	44.77	19.34	99.92
Theoretical.	35.41	....	....	45.26	19.33	100.00

The powder left after analysis No. 1, was digested for two or three days at room temperature with concentrated hydrochloric acid, a little potassium chlorate being added from time to time. The residue was then washed, dried and a sample analyzed, which gave the results under No. II. What remained was digested with silver nitrate solution for a week. Only a very little metallic silver was precipitated, which was removed with dilute nitric acid. The final residue gave the results under No. III. In the analyses, Co, Ni, Fe, and S were determined only once, the arsenic by titrations of two aliquot portions of the same sample.

The chief results of interest are:

1. The regular increase in the amount of cobalt found, with corresponding decrease in the percentage of iron.

2. The fact that the nickel percentage remains practically the same, or perhaps even increases slightly. This result, considered along with the observation of inclusions which appear to resist corrosion better even than cobaltite, appears to point to the conclusion that there is some inert nickel mineral present, intergrown with the cobaltite. It is not unlikely that this mineral is gersdorffite—NiAsS. The progressive decrease in the iron found tends to confirm the suspicion that the iron is present as a mineral rather than in molecular combination replacing cobalt.

Summary—All the evidence—microscopic and analytical—confirms the conclusion that in the case of these cobaltite crystals, the iron and nickel found by analysis can be accounted for by the presence of microscopically visible inclusions of other minerals in the crystals.

There is reason to believe that these included minerals are, for the most part, not later infiltrations or replacements, but are intergrowths with cobaltite, being formed from the same solution at the same time.

Löllingite, Kerr Lake Mine

The specimen in which this mineral was identified is a cross-section of a portion of a calcite vein. One side was originally in contact with the vein wall and contains small angular fragments of decomposed country rock (Figs. 20 and 21).

The vein shows white calcite of two generations (A) and (B), of which (A) appears to be the later, since the base of the löllingite growths (L) rests on (B) and their partially crystallized terminations are embedded in (A). The calcite (B) has a slightly bluish tinge and is readily distinguishable from (A) which is

Fig. 20. Löllingite specimen (natural size).

almost pure white. The löllingite shows a marked fibrous structure with the fibres somewhat radiating, but in a general way normal to the vein walls. Extremely minute fractures filled with calcite traverse the löllingite masses.

On dissolving away the calcite with hydrochloric acid, the löllingite, which is not attacked so long as a little calcite remains, is obtained as radiating fibrous

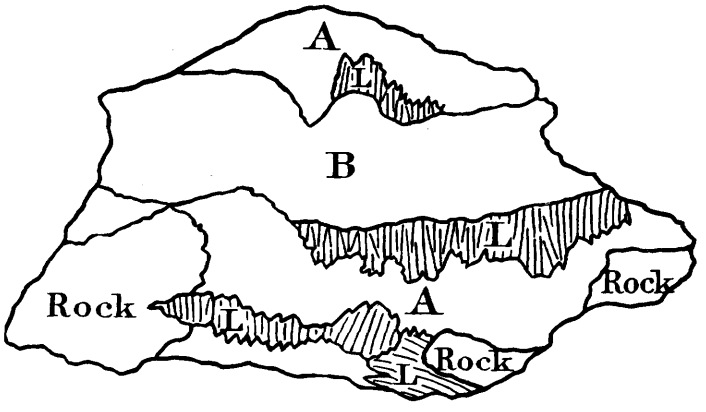


Fig. 21. Diagram of löllingite specimen (natural size).

botryoidal masses. The surface which was embedded in calcite (A) has a velvety appearance and reflects light from very numerous minute sparkling points, which under a microscope are seen to be crystal faces.

Using a binocular microscope, the surface appears to be made up of very small terminated crystals showing minute faces. An attempt to remove some of these for measurement proved fruitless. A few small crystals of arsenopyrite up to .5 mm. diameter are embedded in or attached to the surface.

Examination of polished surfaces etched by acid (Fig. 22) indicates that certain parts are more readily attacked than others, and that the material is far from homogeneous. After a rather severe etching one set of fibres stands in sufficient relief to be repolished by lightly rubbing on fine emery paper, while another constituent is so deeply corroded that it is not affected by moderate rubbing. In fact, three different minerals can be distinguished with certainty, and there are indications of a fourth. The two most important constituents, as will be seen from the analysis, are löllingite ($FeAs_2$) and cobalt diarsenide. The latter, because of the high specific gravity and the fibrous character of the intergrowth, is probably the rhombic form, safflorite. The arsenopyrite previously noted seems to be most abundant toward the outer portions of the growths.

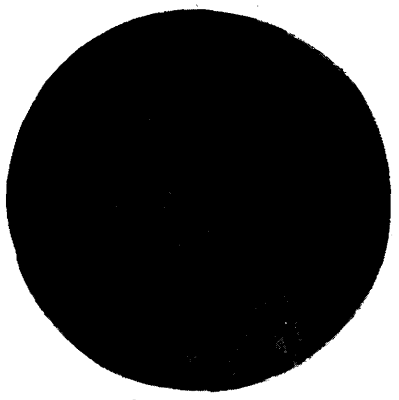


Fig 22. Löllingite surface strongly etched, showing three constituents. Two are bright and stand in relief. The third is deeply etched and appears black in the picture. (x 50).

Analysis—At first only a small sample of about two grams was selected which yielded the following results:

	Fe	Co	Cu	As	S	Sb	Ni	Total
Per cent.	22.18	5.62	.41	70.84	.82	trace	absent	99.87
Mol. Ratio	.3972	.0979	.0064	.9448	.0256	....	....	....
Arsenopyrite Fe As S	.0256	....	....	.0256	.0256	....	....	....
Safflorite $Co\,As_2$	....	.0979	....	.1958	....	....	....	....
Löllingite $Fe\,As_2$	.3617	....	....	.7234	....	....	....	....
Excess	.0099	....	....	....	....	....	....	....

For convenience, the calculations have been made on the assumption that löllingite, safflorite and arsenopyrite of theoretical composition are present. The sulphur has all been calculated as arsenopyrite, but, as will be seen later, there is reason to believe that some of it should be assigned to the copper.

Another sample of about 7 grams was selected with a view to trying some of the separation methods used in other instances. The specific gravity of the sample before grinding was 7.300 at 15.5° C. This sample on analysis gave the following results:

	Fe	Co	Cu	As	S	Sb	Ni	Total
Per cent.	23.60	5.94	.38	69.08	.96	trace	absent	99.96
Mol. Ratio	.4227	.1007	.0059	.9212	.0299	....	....	....
Arsenopyrite (Fe As S)	.0299	....	....	.0299	.0299	....	....	....
Safflorite ($CoAs_2$)	....	.1007	....	.2014	....	....	....	....
Löllingite ($FeAs_2$)	.3449	....	....	.6899	....	....	....	....
Excess	.0479	....	....	....	....	....	....	....

Fe : Co = 1 : 0.251

Compared with the first analysis, this one shows that the mass varies somewhat in composition from place to place, thus confirming the conclusions arrived at by microscopic examination, that the material is an intergrowth of distinct minerals.

As only a small amount of material was available the separation experiments were carried out on about 5 or 6 grams. Only iron and cobalt were determined.

Exp. 1. Concentrated hydrochloric acid with a little potassium chlorate on 250 mesh powder. The filtrate contained relatively much copper.

.0226g Fe and .0054g Co, or Fe: Co = 1: 0.237.

Exp. 2. Silver nitrate solution on 250 mesh powder, filtrate contained .0307 g Fe and .0075 g Co or Fe: Co = 1: 0.244.

Exp. 3. Nitric acid (1 : 1) on 250 mesh powder, filtrate contained .0852 g Fe and .0163 g Co or Fe: Co = 1: 0.191. This treatment was continued and the final residue yielded .1363 g Fe and .0635 g Co or Fe: Co = 1: 0.267.

These experiments for lack of sufficient material could not be carried far enough to obtain definite separations and their value is also lessened because sulphur was not determined, as at that time the arsenopyrite had not been recognized, and it was thought that löllingite and safflorite were the only important variables, whereas, there are certainly three, and possibly five, minerals present. There seems to be, however, no great difference in the solubility of the minerals when in the form of a fine powder, except that the copper mineral, whatever it may be, seems to be more readily attacked than the others. This probably is because the minerals, being closely related chemically and crystallographically, have only small differences in solubility and potential. Furthermore, when finely powdered, the electrical contact between the mineral protected and the protecting mineral is

not so good as in the case of a polished surface, and isolated particles of the protected mineral which do not have some of the protecting mineral attached to them will readily dissolve.

Paragenesis—In a complex intergrowth of this sort it is impossible to separate different periods of precipitation. The growth of the various minerals has been, not in bands parallel to the direction of the vein, nor in concentric layers as we might expect if the mother solution varied in composition from time to time, but in a fibrous aggregate approximately normal to the vein wall and containing the individual minerals side by side. Apparently all the mineral constituents were being formed continuously during the whole period of precipitation, though the percentage of arsenopyrite appears to have increased toward the last. A rather slow, contemporaneous precipitation of the different minerals from a solution of fairly constant composition appears to be the most reasonable explanation of the formation of such an intergrowth.

Summary—There is good reason to credit the cobalt found in the analysis to safflorite. Arsenopyrite crystals were identified by blow-pipe tests and hence the sulphur may be assigned, in part at least, to arsenopyrite. The copper comes off in greatest quantity at first in separation experiments, and probably is present as an easily soluble compound with sulphur. The chief mineral constituent is löllingite.

In short, the material examined appears to be an extremely intimate intergrowth of several minerals closely related, chemically and crystallographically. It is not a single homogeneous mineral containing isomorphous replacing elements in molecular combination. On the other hand it has not been proved that the individual mineral components themselves are not subject to molecular replacement by isomorphous elements.

Arsenopyrite Crystals, O'Brien Mine

Crystals of arsenopyrite from Cobalt have been described and illustrated in Part II. of the Nineteenth Report of the Ontario Bureau of Mines.

The writer in dissolving away the calcite from some of the so-called glaucodot of the O'Brien mine found a residue of detached crystals up to 2.5 mm. across, which it was thought might be glaucodot, but which analysis proved to be arsenopyrite.

The crystals are of a habit which is rather unusual for arsenopyrite, the base being most prominent, followed in order by the prism ∞ (110), and small domes 01 (011) and 10 (101). The base gives multiple reflections and probably consists really of almost infinitely flat pyramids or domes. The drawing (Fig. 23) represents the type habit and characteristic development of the faces. The faces, especially the domes 01, 0$\bar{1}$ are usually corroded, and only two crystals were found to give fairly good reflections. Besides the forms mentioned, which were definitely determined, there also occur corroded traces of the brachypinacoid and of a pyramid in the zone of the prism ∞. One crystal gave very poor readings for a prism which seems to be $\infty \frac{7}{3}$.

An analysis of the crystals yielded the following results:

	Fe	Bi	Co	As	S	Total
Per cent.	34.53	.79	.09	44.34	20.22	99.97

The analysis proves that these crystals are not glaucodot. The presence of bismuth is unusual, though it has been reported in two out of eighty-one analyses of arsenopyrite recorded by Hintze. When examined under a microscope, however, the crystals are seen to be non-homogeneous, which probably accounts for the corrosive effect of the acid on them, as pure arsenopyrite is not much affected by hydrochloric acid.

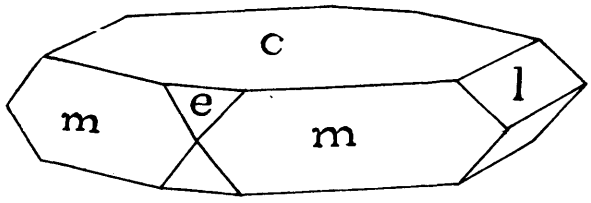


Fig. 23. Arsenopyrite crystal, O'Brien mine.

The finding of arsenopyrite as isolated crystals embedded in calcite and as crystals attached to the arsenide complex, shows that the main arsenopyrite precipitation was later than the main arsenide precipitation, though for a time both were probably being formed together. Bismuth also, in other instances, seems to come later than the period of maximum arsenide deposition, so that its presence here is not remarkable.

Arsenopyrite has been identified in a number of specimens from Cobalt and is probably present in relatively small quantity in most of the complex ore. When intergrown with massive cobalt-nickel diarsenide ore, it cannot be readily detected, except by examining etched surfaces.

Rammelsbergite, University Mine

This specimen at first glance appeared to consist chiefly of very pure niccolite bordered by a band of smaltite from a quarter to a half inch wide, in typical dolomitic vein calcite. On closer examination the supposed smaltite, which analysis shows to be really rammelsbergite, is seen to have the fibrous structure and prismatic cleavage which one associates with the rhombic cobalt-nickel arsenides.

Microscopic observation of etched surfaces shows that the rammelsbergite which is immediately in contact with the niccolite is crystallized, the numerous long, prismatic crystals extending into the niccolite (Fig. 25), and thus proving that the niccolite is the younger of the two.

The niccolite also contains detached crystals of rammelsbergite (Fig. 26) which, in some instances, have been fractured across and the fractures filled with niccolite. The rammelsbergite mass itself is not entirely pure as it contains small inclusions of niccolite which appear to have been precipitated at the same time, though in very much smaller quantity. The niccolite also contains inclusions of

what appears to be breithauptite and possibly of cobaltite, though the latter cannot be identified with certainty because of the nearly square cross-sections of the rammelsbergite crystals, which simulate the cubic crystals of cobaltite.

An analysis of the rammelsbergite yielded the following results:

	Ni	Co	Fe	As	S	Sb	Total
Per cent.	27.84	1.80	trace	67.32	2.03	.83	99.82

Specific gravity at 20°C = 7.157.
Theoretical composition of rammelsbergite, Ni = 28.12 per cent., As = 71.88 per cent.

The analysis indicates that the material is essentially nickel diarsenide. The slight excess of nickel and cobalt over the theoretical percentage is no doubt due

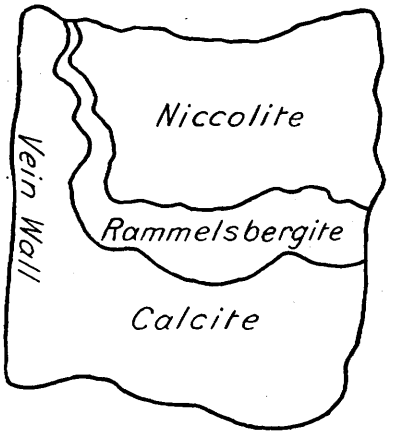


Fig. 24.

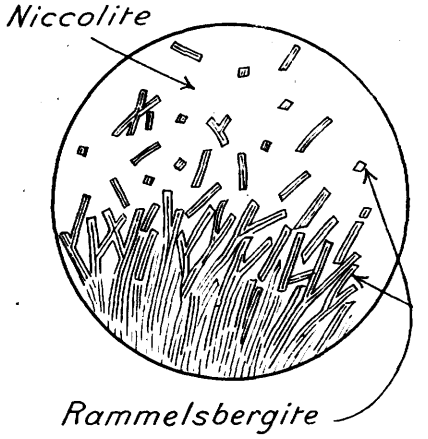


Fig. 25.

Fig. 24. Diagram of rammelsbergite specimen, natural size.
Fig. 25. Drawing of crystallized rammelsbergite at the contact with niccolite, as seen under the microscope.

to the presence of some niccolite, and the antimony is probably in the form of breithauptite associated with the niccolite. The rôle of the sulphur and cobalt is doubtful as cobaltite was not identified with certainty. The long prismatic crystals seen projecting into the niccolite together with the high specific gravity and the well-marked cleavage prove the mineral is the rhombic form—rammelsbergite.

Paragenesis—The fact that the rammelsbergite in contact with the niccolite is crystallized, with the crystals embedded in the niccolite would indicate that the niccolite is the later of the two. Such crystallized surfaces may often be seen in banded veins or vugs in which the growth has undoubtedly been from the walls inwards. The small inclusions of niccolite which occur in the rammelsbergite are probably due to simultaneous precipitation of a small amount of niccolite during the formation of the rammelsbergite. The composition of the mother solution which at first precipitated rammelsbergite with a little niccolite, must have altered in such a way that the amount of niccolite formed was increased until only a small amount of rammelsbergite was being precipitated along with the niccolite. At a

point about a quarter inch from the edge of the massive part of the rammelsbergite, only scattered, isolated crystals can be seen in the niccolite, which appears to the naked eye to be very pure.

That the structure just described could be due to replacement of either mineral by the other, appears to be improbable. If niccolite replaced rammelsbergite the crystals would have suffered more severely. They are, on the contrary, very perfect and entirely uncorroded. If rammelsbergite be supposed to have replaced niccolite one would have difficulty in explaining the presence of perfect, isolated crystals of rammelsbergite embedded in niccolite at considerable distances from the main rammelsbergite mass.

The relationship between rammelsbergite and niccolite thus appears to support the theory which will be developed later, of the general order of precipitation at Cobalt, i.e., diarsenides first, followed by monarsenides, these by sulpharsenides, and finally sulphides and disulphides, with native silver.

Fig. 26. Long prismatic crystals of rammelsbergite in niccolite.

Glaucodot, O'Brien Mine

Glaucodot has been mentioned as occurring at Cobalt, but its presence has not been proved[20]. Having examined a large quantity of the material from the O'Brien mine, which has long been supposed to contain glaucodot, the writer is satisfied that the complexity of the material is such that the presence of glaucodot cannot be confirmed. The reasons for this opinion will appear later.

On dissolving away the calcite from some of this material, numerous small tabular crystals up to 2 mm. in diameter were obtained. It was thought that these might be glaucodot. They were measured on the two circle goniometer, but, while the signals were not very good, the readings indicated that the mineral might be either arsenopyrite or glaucodot. They were then analyzed and found to be arsenopyrite, containing .09 per cent. of cobalt. Another lot of crystals of different habit proved to be arsenopyrite also.

The massive material was then examined by etching a number of polished surfaces, and it proved to be a very complex intergrowth of five or six different minerals, often in a very finely divided condition. Some of the larger structures can be seen with a hand lens, but the microscope shows that the whole is a mixture of grains,

[20] Pt. II, 19th Report, Ont. Bur. Mines, p. 22.

often of extremely small size, sometimes cencentrically arranged (Fig. 27), sometimes irregularly distributed like the grains in a section of granite. The main constituents appear to be smaltite, arsenopyrite and pyrite with small amounts of what appears to be niccolite or breithauptite—perhaps both. On treating a fragment with hydrochloric acid till the arsenides are partly dissolved, a thin network of native silver is revealed.

A sample of the mass was analyzed with the following results:

	Ag	Co + small amount of Ni	Fe	Bi	Cu	As	S	Quartz	Total	Sb
Per cent	2.12	$\frac{17.34}{58.97}$=.2941	$\frac{10.28}{55.84}$=.1799	.95	.09	$\frac{60.77}{74.96}$=.8106	$\frac{8.08}{32.07}$=.2520	.12	100.22	.47

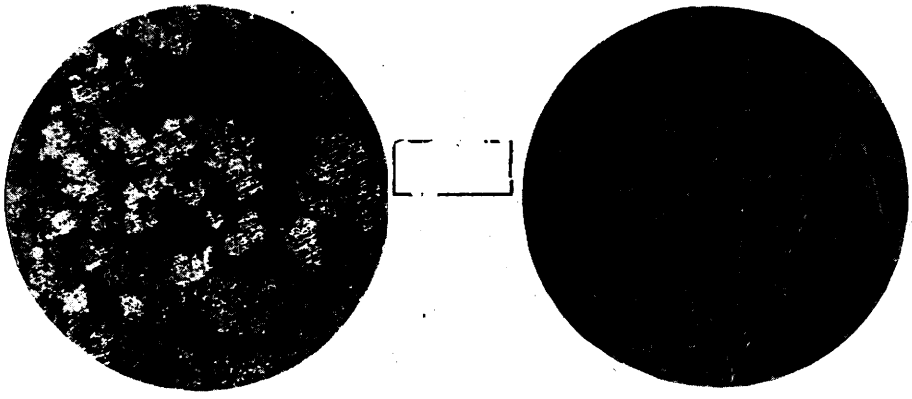


Fig. 27. Fig. 28.

Fig. 27. Concentric structure, representing an intergrowth of several different arsenides. The black central part is more or less square in outline, suggesting a cube of smaltite or chloanthite.

Fig. 28. Matildite inclusions (dark), in light ground mass of galena.

This material serves very well as an example of the extreme microscopic complexity of much of the Cobalt ore. There appears to be no evidence, however, which would lead to the supposition that glaucodot is one of the constituent minerals.

After examining a considerable quantity of the massive material microscopically, another sample, which was apparently purer than the first lot, was selected and analyzed, with results as below:

	Co	Fe	Ni	As	S	Cu, Bi, Ag and Sb	Total
Per cent.	$\frac{17.22}{58.97}$=.2920	$\frac{10.79}{55.84}$=.1933	$\frac{1.80}{58.68}$=.0307	$\frac{63.14}{74.96}$=.8422	$\frac{6.75}{32.07}$=.2105	trace	99.70

The ratios here are much the same as in the first analysis, but smaller amounts of copper, bismuth and antimony are present. There is no evidence that glaucodot is one of the constituents.

Summary—The material is a complex microscopic intergrowth of several minerals, which are so intimately mixed that they cannot be definitely assigned to

different periods of precipitation though the arsenopyrite, pyrite and chalcopyrite were formed chiefly at the last. Cobalt diarsenide (smaltite or safflorite) and arsenopyrite with less pyrite or marcasite are the predominant minerals of the complex. Several others such as niccolite, löllingite, breithauptite are indicated by etching tests and analysis. Native silver and probably native bismuth and chalcopyrite are present in small amounts. There appears to be no reason to suppose that glaucodot is one of the constituents, knowing as we do that arsenopyrite and pyrite are present.

Here, again, all the facts point to slow simultaneous precipitation of several minerals from a solution which varied but slowly in composition, the sulpharsenides and sulphides predominating during the last stages of the deposition.

Matildite-Galena intergrowth, O'Brien Mine

The specimen examined was a small mass of galena in which certain areas were remarkable because of their whiter colour and brighter lustre, and also because of a disturbance of the normal cubic cleavage which in such parts assumes a distorted, roughly rhombohedral form. Microscopic examination of an etched surface (Fig. 28) shows that this last material is an intergrowth of two distinct minerals, of which the ground mass is galena and the included mineral, as shown by the accompanying analysis, is matildite.

	Pb	Bi	Ag	S	Sb	Fe	Total
Per cent.	54.35	20.26	10.11	14.68	.45	.20	100.05
Mol. Ratio.	.2624	.0974	.0937	.4580	.0037	.0036	....
Galena PbS	.2624	....	....	.2624	....	....	....
Matildite $AgBiS_2$	....	.0937	.0937	.1874	....	....	....
Excess	....	.0037	....	.0080	.0037	.0036	....

Specific gravity at 21° C = 7.201.

The somewhat inexact ratios shown by the analysis may be due partly to the difficulties of the chemical separations. The rôle of the iron and antimony found is doubtful. It is evident, however, that the material is essentially an intergrowth of galena and matildite in the approximate proportion of: Galena 62.76, and Matildite, 36.50 per cent.

Paragenesis.—The specimen described was a small mass of the material associated only with galena and traces of calcite, so that it was impossible to ascertain the relationship of matildite to the common minerals of Cobalt.

Microscopic examination of etched surfaces shows that the intergrowth is of a very intimate and uniform character. Any section taken at random, throughout

the mass, shows the same characteristic structure. There is no arrangement of the matildite particles along cleavage lines or cracks in the galena as might be expected if the structure were due to metasomatic replacement of galena by matildite. That the perfect cleavage of galena persists in the intergrowth, though in a slightly distorted form, and the very fact that the cleavage is distorted so that it is no longer exactly cubic, along with the isolated, discontinuous character of the matildite inclusions, seems to the writer to be evidence as conclusive as can be expected of the simultaneous precipitation of the matildite and galena.

Further, in all occurrences of matildite recorded by Dana and Hintze from widely separated regions of the world, this mineral has been intimately associated with galena. All the analyses on record show a lead content, varying from 2.58 to 8.00 per cent., and in every case the lead has been reported by the analyst as galena. There are many examples of such pairs of minerals which very often occur as intergrowths, even when in crystals, as in the case of smaltite and chloanthite. Such intergrowths can hardly be explained in any other way than by supposing that the two constituent minerals were being formed continuously during the period of crystallization.

The fact that matildite from such widely separated localities as Peru, Colorado, Japan and Ontario is always very intimately associated with galena is rather remarkable, and would seem to have some special significance.

Proustite from Cobalt, Ont., O'Brien Mine (?)

Crystals of proustite, supposedly from the O'Brien mine, have been described in detail by A. L. Parsons of the University of Toronto, and were analyzed by the writer. The following extracts from the article[21] referred to may be quoted:

The crystals for the most part are less than two millimetres in length and very few exceed a millimetre in diameter. They are light ruby-red in colour and exceedingly brilliant, and casual inspection suggested that they were proustite. As this mineral had not been described from the Cobalt region, it seemed desirable to confirm this supposition by chemical analysis and crystallographic measurement.

The material for analysis was obtained by floating the crystals from a large quantity of fine material which had broken away from the larger specimens. In this operation it was found that certain impurities accompanied the proustite, so that the final separation was made by means of a brush and lens. It was observed that many of the crystals still had a trace of what appeared to be smaltite attached to one end, but with the material at hand it did not appear feasible to remove the last trace of impurity.

It was also observed that in some instances the crystals were somewhat dark for proustite, and in most cases these were discarded, but the small amount of antimony found in the analysis would indicate that a little pyrargyrite is mingled with the proustite.

The analysis yielded the following results:

	Ag	As	S	Sb	Fe	Co (with trace of Ni)	Insol. in HNO_3	Total
Per cent.	64.12	15.90	19.28	.08	.25	.12	.38	100.13

The percentages for silver, arsenic, sulphur and iron are the averages of two determinations for each. The determinations for antimony and insoluble were made only once, while the cobalt-nickel determination was obtained by combining the cobalt-nickel contents of two analyses.

[21] Proustite from Cobalt, Ont., by A. L. Parsons, in Mineralogical Magazine, Vol. XVII—No. 82—April, 1916.

If we assume that the iron is combined with sulphur in the form of pyrite and the cobalt with arsenic in the form of smaltite, the recalculation gives a nearly pure proustite with a small excess of arsenic as follows:

Element	Ag	As	S	Sb	Fe	Co
Per cent.	64.12	15.90	19.28	.08	.25	.12
Mol. Ratio	.5943	.2120	.6013	.0007	.0045	.0020
Pyrite	....	....	.0090	....	.0045	....
Smaltite	....	.0040	....	....	....	.0020
Proustite	.5922	.1974	.5922	....	....	....
Pyrargyrite	.0021	....	.0021	.0007	....	....
Arsenic excess	....	.0106	Deficiency of S = .0020	....	....	....

Converting these ratios into percentages the following result is obtained:

	Proustite	Pyrargyrite	Smaltite	Pyrite	Arsenic excess	Insol.	Total
Per cent.	97.69	.39	.42	.53	.79	.38	100.19
						Less S added	.06
							100.13

Owing to an error in calculating the molecular ratio for antimony in the original paper, the percentages of the mineral constituents given here differ slightly from those tabulated in the paper by Mr. Parsons.

Polybasite Crystals, O'Brien Mine

Polybasite has long been supposed to be present in the Cobalt ores, but hitherto has not been positively identified by crystallographic measurements or chemical analysis.

Several years ago M. T. Culbert, of the O'Brien mine, presented to the museum of the University of Toronto, a specimen of argentite, showing a few minute crystals, which he believed to be polybasite, because of the triangular striations to be seen on some of the faces.

The writer examined this specimen with a view to extracting crystals for measurement. The minute, brilliant, thin tabular crystals, reaching a maximum diameter of perhaps two millimetres, are always firmly attached to the argentite, either by the large basal pinacoid or by one side, and had to be very carefully cut away. Finally, about ten crystals, together with some broken material, were

obtained. These were examined on the goniometer and all showed the same characteristic habit, but only one, which was about one millimetre in diameter, gave fairly good reflections. This one was measured as accurately as possible. The best readings for the side faces gave values of 59° 46′, 60° 05′ and 59° 10′ for the outer angles between these faces, which agree closely with the values given by Penfield (60°02′) and Goldschmidt (60°01′) for the prism *m*: *m*. The base, as nearly as could be ascertained, was at 90° to the side faces. The vicinal faces, indicated in the drawing (Fig. 29), gave a continuous hazy band of light in which no definite points could be observed, from about 16° to about 44° from the base. This crystal had been attached by one side, and the lower half of the crystal showed exactly the same arrangement of vicinal faces as the upper, but because of the fragile nature of the crystal, no attempt was made to measure the vicinal faces on the lower half. The side faces which correspond to the prism m (110) are slightly concave, causing distortion of the signals, and a fracture parallel to the base divides the crystal

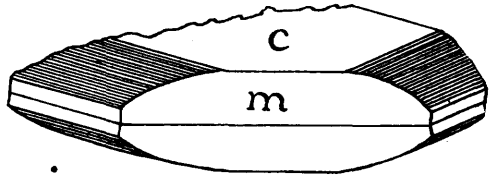


Fig. 29. Polybasite, O'Brien mine.

symmetrically into two equal parts, thus displaying perfect basal cleavage. This fracture was doubtless developed by cutting the argentite from around the crystal. Considered along with the re-entrant character of the prism faces, it suggests a twinning parallel to the base.

Polybasite has been considered by different authors to be either rhombic or monoclinic with twinning plane m, and probably also with a twinning like the micas, parallel to the base. Penfield, who is responsible for much of the later work on polybasite, considers it monoclinic, on both crystallographic and optical grounds.

Using the high power of the microscope, small, very thin particles of these crystals appear translucent and of a bright cherry red colour. This character distinguishes polybasite from the corresponding arsenic compound—pearceite, which is said to be "opaque even in the thinnest splinters."[22] The crystals are very brittle and rather soft. H = 2.5 to 3. Colour and streak black, lustre metallic, cleavage basal.

In order to further confirm the identification of these crystals as polybasite, the broken fragments obtained in trying to remove the crystals from the argentite were combined with those crystals which had proved useless for measurement and about 20 milligrams of powder was thus collected for analysis. Weighings were made only to the usual four places of decimals on a good balance and the analysis was necessarily at the same time both qualitative and quantitative, so that no great accuracy was attained. The results, however, confirm the decision, reached by means of crystallographic methods, that the mineral is polybasite.

[22] Hintze—Handbuch der Mineralogie.

Analysis of polybasite crystals:

	Ag	Cu	Sb	S	Total
Per cent.	74 to 75	2	6+	12+	95
Theoretical $Ag_9 Sb S_6$	75.67	....	9.34	14.99	100.00

Reviewing all the evidence it is found that these crystals agree in form, physical properties, and chemical composition with the mineral polybasite $(Ag,Cu)_9 SbS_6$, which is thus definitely established as a Cobalt mineral.

It was thought that the argentite to which the polybasite crystals were attached might show an admixture with massive polybasite, especially as certain spots showed an unusual brilliant, superficial tarnish like bornite. An analysis (page 208), however, yielded no more than traces of antimony and copper as impurities, so that there is no evidence to show that massive polybasite is present in quantity.

Pink Carbonate

An oxidized arsenide specimen from the O'Brien mine showed velvety coatings, one to two millimetres thick, consisting of very delicate needle-like crystal growths. On some parts of the specimen this coating was pure white, on others, a beautiful peach blossom pink. It was thought that the pink material might be roselite and it was accordingly analyzed.

Fe	2.33	per cent. =	4.83	per cent.	Fe CO_3
Co	0.80	" =	1.35	"	Co CO_3
Ca O	51.13	" =	91.53	"	Ca CO_3
Mg	.64	" =	2.21	"	Mg CO_3
		Total.....	99.92		

The material is evidently merely calcium carbonate with small amounts of iron and cobalt which give the colour. From optical tests and habit of growth it appears to be arragonite rather than calcite.

Symplesite, Penn-Canadian Mine

This material was examined because it was thought it might contain cobalt oxides such as heterogenite or heubachite which have been supposed to be present in some of the oxidized Cobalt ores.

The specimen represents weathered, oxidized ore such as was obtained at the surface in opening up the Cobalt veins. It consists of earthy masses of bluish black oxidized material, held together by spongy native silver or dyscrasite. In some spots a dirty pink colour indicates the presence of impure erythrite.

Under the microscope, the earthy material is seen to consist for the most part of grains which, when thin, are translucent to transparent, yellowish in colour and doubly refracting. Along with these are other opaque grains which are chiefly native silver or dyscrasite, and argentite.

Chemical Properties—The earthy part is readily soluble in five per cent. hydrochloric acid, and no unoxidized arsenides were detected in the residue. The insoluble part consists chiefly of native silver or dyscrasite, and argentite, with small grains of quartz. The argentite is not attacked by hydrochloric acid of this concentration, and no sulphur is found in the filtrate, showing that all the sulphur

obtained in the analysis is to be assigned to argentite. Qualitative tests show that the iron is practically all in the ferrous condition, though a very small amount of ferric iron was detected. On treating with strong hydrochloric acid no chlorine is evolved, showing that the cobalt and nickel are also in the lower state of oxidation. Water-soluble arsenic trioxide was not detected, neither by long standing (three weeks) with occasional shaking, at room temperature, nor by boiling for an hour or more.

Preparation of Samples—The material was gently rubbed in an agate mortar and two portions were separated for analysis.

1. Arsenate Part: The powder which passed a 250 mesh sieve. This was chiefly arsenates with particles of native silver or dyscrasite and argentite. The hope that the very fine sieve would eliminate most of the native silver proved to be unjustified because of the brittleness of the so-called silver which may be judged by the fact that the analysis indicates the presence of about 18 per cent. in this sample, all of which of course, had passed through the fine sieve along with the arsenates, after only moderate rubbing. The brittle character of the silver would lead one to suspect that it was really dyscrasite.

2. Silver Part: This constitutes the coarser, less brittle portions left behind on the sieve. These were freed from adhering arsenates by dilute hydrochloric acid, rinsed with ammonia to remove any silver chloride and then washed to get rid of small particles of argentite.

These two samples were analyzed with the following results:

Analysis of the arsenate part:

Element	Per cent.	Mol. Ratio	Argentite Ag_2S	Native Silver. Dyscrasite and Amalgam	Symplesite $Fe_3As_2O_8 \cdot 8H_2O$	Erythrite $Co_3As_2O_8 \cdot 8H_2O$	Annabergite $Ni_3As_2O_8 \cdot 8H_2O$	$R_3As_2O_8 \cdot 8H_2O$ R=Cu, Ca, Mg, Al
Ag	28.11	.2605	.1066	.1539	....	....	....	....
S	1.71	.0533	.0533	....	....	....	....	....
Sb	.79	.0066	....	.0066	....	....	....	....
Hg	.64	.0032	....	.0032	....	....	....	....
FeO	7.71	.1074	....	....	.1074	....	....	....
CoO	6.31	.0842	....	....	....	.0842	....	....
NiO	1.74	.0233	....	....	....	....	.0233	....
CuO	2.42	.0304	....	....	....	....	....	.0304
As_2O_5	24.60	.1070	....	....	.0358	.0281	.0078	.0301
Sb_2O_5	1.55	.0048	....	....	....	....	....	....
*H_2O	13.64	.7577	....	....	.2864	.2245	.0622	.2512
CaO	2.58	.0460	....	....	....	....	....	.0460
MgO	.72	.0638	....	....	....	....	....	.0638
†CO_2	(2.81)	.0638	....	....	....	....	....	....
‡CO_2	.73	....	....	....	....	....	....	....
Al_2O_3	.30	....	....	....	....	....	....	....
Quartz	4.45	....	....	....	....	....	....	....
	(100.08) 98.00							

* Direct determination of total water. H_2O at 100°C not determined.
† Equivalent to CaO and MgO found.
‡ Actually found. One determination.

Analysis of silver part:

	Ag	Hg	Sb	Argentite Insol.	S	Total
Per cent.	90.54	3.08	.79	5.50	trace	99.91

The arsenate sample could not be dried at 100° C. as it loses water, at first rapidly, then slowly, but continuously at that temperature. One gram heated for a half day at 100° C. lost 4.87 per cent.; one gram heated another half day, .22 per cent.; one gram heated another half day, .14 per cent. After allowing this dried sample to stand in the open for three days it had regained its original weight. In order to secure uniform sampling, the material, without previous heating, was all weighed out at one time into gram quantities and kept in clamped watch-glasses till required.

The duplicate analysis of the arsenate part gave closely concordant results, but there is some uncertainty as to the way in which some of the actual analytical results should be recalculated, and certain assumptions have been made which may not be altogether justifiable. For example, the total antimony found has been divided into two portions as Sb, and Sb_2O_5. The amount of antimony found in the silver part has been tabulated as such in the arsenate part, assuming it to be in the form of dyscrasite, but it is not improbable that the silver which was mixed with the arsenates was richer in antimony than the coarser, more ductile sample analyzed as part 2, and, therefore, a larger proportion of the total antimony should really be deducted to make dyscrasite. An attempt was made to analyze the silver mixed with the arsenates by extracting the arsenates with dilute hydrochloric acid, but the silver was in such a finely divided condition that even the dilute acid changed it almost completely to the chloride while mercury and antimony passed into solution. A titration with permanganate of a sulphuric acid solution of the arsenates made in an atmosphere of carbon dioxide gave almost exactly the same results for iron as the gravimetric determination. Carbon dioxide is believed to be present in much smaller amount than would be required to combine with the CaO and MgO found. The single carbon dioxide determination on about 2 grams of material could not be expected to give results of great accuracy, but the quantity found confirms the suspicion that the lime and magnesia are not present entirely as carbonates. When the material is treated in a small test-tube with strong hydrochloric acid, a slight evolution of gas can be detected with a hand lens, but would not be noticed by the naked eye. In fact, the presence of carbonates was not suspected until analysis revealed calcium and magnesium in the mixture. Calcium and magnesium are often found in considerable quantity in the arsenates of this series and no doubt in this case, also, are chiefly in the form of arsenates.

Mineral Constituents.—From the foregoing chemical data the mineral composition of the mixture has been calculated as indicated in the table. All the sulphur is combined with silver to form argentite. Mercury and the amount of antimony found in the silver part (2) are associated with the rest of the silver as dyscrasite and amalgam. It may be noted that the amount of mercury relative to silver is

approximately the same in both analyses, but is a little higher in the more brittle silver of the arsenate part.

In arsenate part Ag: Hg = 16.61: 64
In silver part Ag: Hg = 90.54: 3.08

Since the iron is in the ferrous condition it has been calculated as symplesite, the iron arsenate corresponding to erythrite and annabergite. Symplesite has not been recognized hitherto in Cobalt ores, though it might be expected to occur. Cobaltous and nickelous oxides are calculated to erythrite and annabergite respectively.

So far there can be little doubt that the calculation represents the true mineral composition. There are, however, many arsenates of copper, while calcium and magnesium arsenates are known, and these elements may also replace cobalt or nickel in erythrite and annabergite, according to analyses recorded by Dana. If a compound $R_3As_2O_8$. 8 H_2O (R= Ca, Mg, Cu Al) analogous to erythrite be calculated for the lime, magnesia and copper oxide found then small amounts of arsenic and antimony pentoxides remain uncombined and a little more water than was found in the analysis is required. Certain of the copper, calcium, and magnesium arsenates, however, contain less water and more arsenic than the assumed compound and some of these may be present. The excess of arsenic would also be explained if a small amount of native arsenic were present. If so, it must be in a very finely divided condition and would be difficult to detect.

The percentages of the different minerals so far as they may be definitely calculated are given below:

	Argentite	Native Silver with Sb and Hg	Symplesite	Erythrite	Annabergite	Arsenates of Cu, Ca, Mg, etc.	Quartz	Total
Per cent.	13.21	18.04	21.09	20.60	4.65	about 18.00	4.44	100.03

Earthy Scorodite and Erythrite, Temiskaming and Hudson Bay Mine

The erythrite of Cobalt occurs usually as earthy incrustations on oxidized smaltite, crystallized material being rather uncommon. A sample of the earthy material of yellowish pink colour from the Temiskaming and Hudson Bay mine was examined for free arsenic trioxide and incidentally was found to contain a relatively large amount of ferric iron. This appeared to indicate the presence of scorodite, so the sample was analyzed with results as below:

	Fe_2O_3	CoO	NiO	As_2O_5	H_2O (total)	CuO	As_2O_3 (Sol. in H_2O)	Insol.	CaO	S	Total
Per cent.	8.73	21.43	3.95	38.45	24.22	small am'u't	trace	2.90	trace	trace	99.68
Atomic Ratio	.0547	.2859	.0529	.1673	1.346	....	....	....	....	....	....
Scorodite $Fe_2O_3 \cdot As_2O_5 \cdot H_2O$	.0547	....	....	.0547	.2188	....	....	....	....	....	....
Erythrite $Co_3As_2O_8+8H_2O$	....	.2859	....	.0953	.7624	....	....	....	....	....	....
Annabergite $Ni_3As_2O_8+8H_2O$	....	....	.0529	.0176	.1408	....	....	....	....	....	....
Excess	....	....	....	.0003	.224	....	....	....	....	....	....

On gently rubbing the material to a powder, the yellowish tint became more prominent and when some of the larger lumps were broken open, yellow spots were visible which were found to be chiefly ferric arsenate. The copper appears to be associated with the scorodite. Only a trace of water-soluble arsenic trioxide was obtained after treating the material with water for three weeks at room temperature. The total water obtained in the analysis probably includes more or less merely hygroscopic water, and perhaps, may also represent a slight loss of arsenic acid. The arsenic determinations were made on separate portions. Qualitative tests show that the iron is all in the ferric condition. The analytical results thus indicate that an important amount of scorodite is present in this earthy arsenate material.

On Isomorphism as Displayed by Certain Minerals from Cobalt

Analyses of even the most carefully selected samples of apparently pure, simple minerals from Cobalt such as, say, niccolite or smaltite, have, in the writer's experience, invariably revealed the presence of so-called isomorphous replacing elements, e.g., Fe Co, Sb and S in niccolite, Ni, Fe and S in smaltite. Such an experience is, moreover, not at all unusual, as witness the numerous similar analyses in any handbook on mineralogy. It has been usual with most mineralogists to regard such foreign elements as replacing in a molecular way a corresponding amount of the elements essential to the pure mineral. The writer, in examining polished surfaces of such minerals after etching with acid, has always found inclusions of one or

more different minerals present which might easily account for the foreign elements found by analysis. As has been seen in the case of cobaltite and smaltite, even the most perfect crystals may contain considerable amounts of foreign minerals either as inclusions or intergrowths. Such inclusions are very likely to be a mineral or minerals similar in crystal symmetry and analogous in chemical composition to the including mineral, e.g., the inclusions of niccolite in breithauptite (Fig. 8), or the smaltite-chloanthite intergrowth (Fig. 17). This is not always the case, however, examples of the latter type of intergrowth are furnished by inclusions of cobaltite (cubic) in niccolite (hexagonal), Fig. 13, and rammelsbergite (rhombic) in niccolite, Fig. 26. The former type of associations appears to be mixtures or intergrowths of more or less related, or isomorphous individual minerals, rather than homogeneous molecular mixtures.

Most of our knowledge of isomorphism rests on the data of chemical laboratory experiments. Nernst[23] refers to isomorphous mixing as "the capacity of two crytallized substances for uniting to form a homogeneous mixed crystal." Retgers[24] speaks of "the property of forming solid molecular mixtures." The chemist takes special precautions in order to obtain homogeneous mixed crystals. Retgers recommends in making mixed crystals, that "in order to obtain a product as homogeneous as possible, it is best to use a large quantity of solution and to study only the crystals which separate first."

In nature, however, these ideal conditions are probably seldom realized, and in the case of the arsenides and sulpharsenides of Cobalt, at least, the result is oftener a very intimate mixture or intergrowth of the two isomorphous substances than a true homogeneous molecular mixture, even when good crystals are formed. The etching methods described in the introduction enable us to distinguish very definitely the different components of such a mixture. The separation experiments performed on certain of these mixtures, e.g., niccolite-breithauptite, smaltite-chloanthite, seem to show that the individual components may be precipitated side by side as minute particles in extremely intimate microscopic mixtures or intergrowths and still retain their chemical identity and purity. There is this difficulty, however, with such etching separations, that only the residue may be expected to be pure and homogeneous, and if such a pure residue is obtained, it does not prove that some of the material which dissolved was not a homogeneous molecular mixture. It seems certain, however, that in most of the mixtures examined by the author, the amount of material which may represent true isomorphous molecular mixtures must be small compared to the amount which exists as pure chemical individuals.

Whether special conditions of precipitation were responsible for this character of the Cobalt minerals or whether it is a general characteristic of the arsenide and sulpharsenide groups of minerals, is a problem for the future. Baumhauer[25] and Vollhard[25] were the first to show that crystals of smaltite or chloanthite (from European localities) were really intergrowths, the different parts of which varied in composition. The writer suspects that such intergrowths are general among the minerals of these groups and that true molecular isomorphous replacements or mixed crystals are correspondingly rare.

[23] W. Nernst—Theoretical Chemistry.
[24] Idem, page 109.
[25] Loc. Cit.

It appears to the writer that such structures as the smaltite-chloanthite and the niccolite-breithauptite intergrowths afford some evidence of the degree of isomorphism exhibited by the minerals concerned, granting, of course, that these structures have resulted from practically simultaneous precipitation of the constituents from the same mother solution. The term isomorphism, of course, implies more or less complete identity of crystal symmetry. In this sense, these minerals are isomorphous. The property of mutual overgrowth is possessed by substances which have not the slightest chemical or crystallographic similarity and has accordingly been rejected by Retgers as conclusive evidence of isomorphism. Accepting complete miscibility or the property of forming homogeneous mixed crystals in all proportions as the most decisive criterion of pure isomorphism, as advocated by Retgers, we are led to the conclusion that the minerals with which we have been dealing, such as niccolite-breithauptite, smaltite-chloanthite, probably do not form molecular mixtures in every proportion and, therefore, do not exhibit the highest degree of isomorphism, in spite of their similar crystal form and analogous chemical composition. The same holds true for the cobaltite crystals with their gersdorffite (?) inclusions.

Following the classification of miscibility according to Retgers, these minerals appear to display limited miscibility of a sort.

Order of Deposition of Cobalt Minerals

The writer has not been concerned primarily with the study of the paragenesis of Cobalt minerals, but the apparent order of formation has been indicated for the associations which have come under his observation. For a complete study of this question very complete data would be necessary and final conclusions are probably

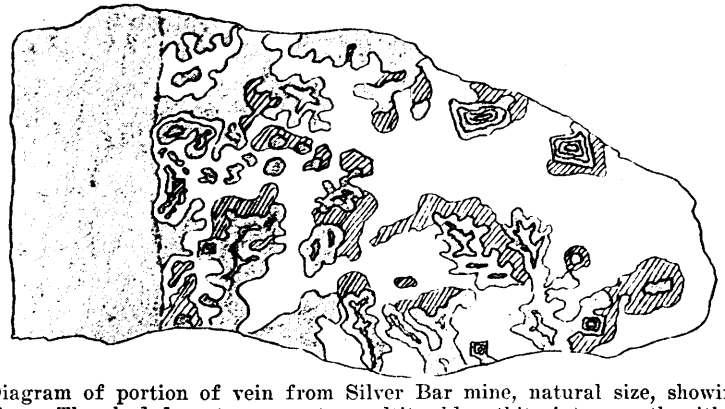


Fig. 30. Diagram of portion of vein from Silver Bar mine, natural size, showing order of deposition. The shaded part represents smaltite-chloanthite intergrowth with chloanthite in the centre of dendritic growths. The hatched part is later niccolite and the white is calcite.

not justified by a microscopic study of isolated specimens alone. As the writer's conclusions, however, agree in the main with those of W. G. Miller and C. W. Knight, they are here summarized.

From the numerous extremely intimate intergrowths which have been observed among the Cobalt minerals, e.g., smaltite-chloanthite, niccolite-breithauptite, etc., it is believed that certain of these minerals were precipitated in greater or less

quantity at the same time. The structures observed appear to indicate that the mineralizing solutions at first were relatively very rich in arsenic and during this time intergrowths of diarsenides-smaltite and chloanthite—were chiefly precipitated. The arsenic content of the solutions gradually diminished and monarsenides-niccolite and breithauptite—were for a time predominately deposited. The arsenic continued to decrease in amount and sulphur became prominent, so that sulpharsenides, such as cobaltite and arsenopyrite, were deposited. Finally, the arsenic in solution was reduced to a very small quantity, and calcite was deposited. A period of fracturing ensued and the solution which may now have been of either a sulphate or carbonate character circulated through the fractured veins. From this solution native silver and argentite were precipitated by the action of arsenides and calcite, resulting in such silver replacement structures as we have seen (Fig. 30).

It is believed that the process of deposition of the various arsenides and sulpharsenides was more or less continuous, and that, though a period of maximum deposition for any one of these minerals may be distinguished, there is, nevertheless, no sharp dividing line between the different periods.

The apparent order of deposition from the writer's observations may be indicated in tabular form as follows:

I. Arsenides and Sulpharsenides
- 1. Diarsenides — $NiAs_2$, $CoAs_2$
- 2. Monarsenides — NiSb, NiAs
- 3. Sulpharsenides — Co As S, Fe As S

II. Calcite, followed by fracturing.

III. Native silver and argentite, native bismuth, sulphides and sulpho-salts.

IV. Decomposition products—arsenates of cobalt, nickel, iron, copper, and calcium.

In conclusion, the writer wishes to thank T. L. Walker, Professor of Mineralogy at the University of Toronto, not only for much kindly advice and encouragement, but also for the original suggestion which initiated this work.

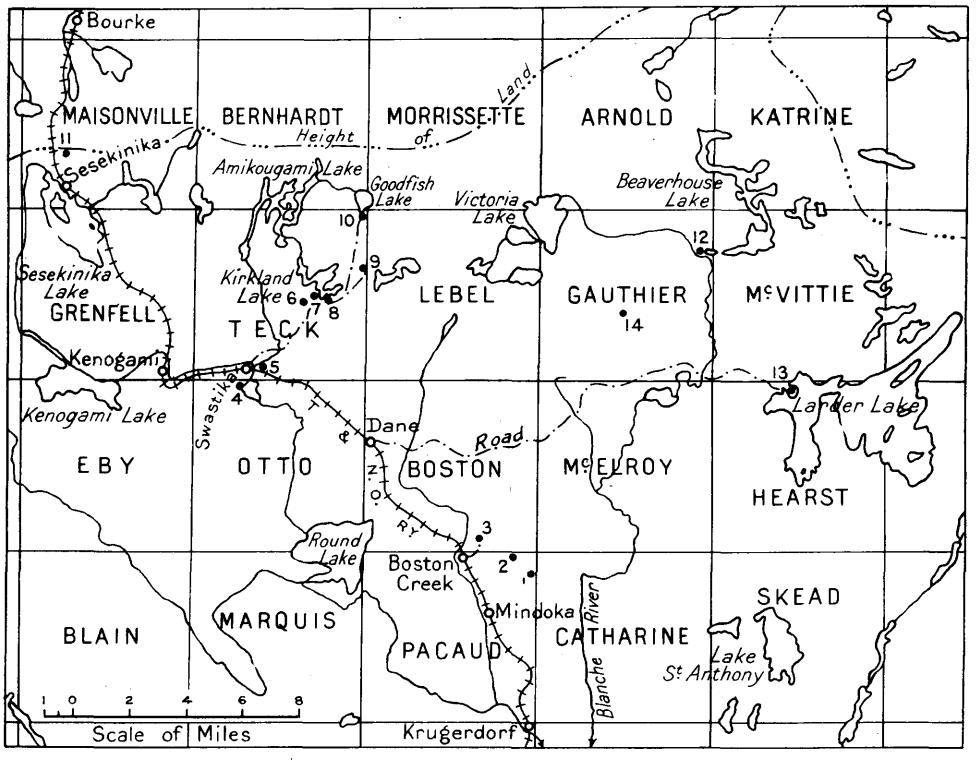
BOSTON CREEK GOLD AREA

By

A. G. BURROWS and P. E. HOPKINS

Introduction

That part of Boston, Pacaud, McElroy and Catharine townships in the vicinity of Boston Creek is spoken of herein as the Boston Creek gold area. The region is situated in the district of Timiskaming, about 45 miles northwesterly from Cobalt, and is traversed by the Timiskaming and Northern Ontario railway. Boston Creek station, mileage 153.5, is approximately in latitude 48° north and longitude 80° west. By rail, Boston Creek station is 382 miles north of Toronto.



Sketch map showing the locations of some of the gold properties mentioned in the reports on Boston Creek and Goodfish Lake areas:

1. Miller-Independence
2. McRae
3. R. A. P. Mining Co.
4. Swastika
5. Lucky Cross
6. Kirkland Lake Mines
7. Teck-Hughes
8. Lake Shore
9. Tough-Oakes
10. La Belle Kirkland
11. Smith-La Bine
12. La Mine D'Or Huronia
13. Goldfields, Limited
14. Elstone-Dunkin Mines, Ltd.

Claims were staked for gold in this area in 1906 and 1907 during the days of the Larder Lake gold rush. Again in 1913, during the activity at Kirkland lake twelve miles to the northwest, many claims were re-staked and some work

was done on them. Since May, 1915, John Papassimakes has had a number of men at work on what is known as the Kenzie vein, on claims L 3665 and L 5163, in the south central part of Boston township. The promising development work on the Kenzie vein attracted many prospectors to the area, and several other gold discoveries were made in the four townships. Considerable prospecting, particularly on the surface, was done during 1915, but as yet no bullion has been shipped.

A railway station has been erected near the crossing of Boston creek, around which has grown a small settlement.

Part of the Boston Creek area was included in the map[1] of the Kirkland Lake and Swastika gold areas. During September and October, 1915, the writers examined about 70 square miles, including Pacaud and parts of Boston, McElroy and Catharine townships. Owing to the lateness of the season and the extremely wet weather, a part of the area was examined only in a general way. A coloured geological map[2] of this area, showing the main rock outcrops on a scale of three-quarters of a mile to the inch, accompanies the report.

Boston Creek station, T. & N. O. railway, showing hotel on the right, and the stream valley and railway bridge on the left. *May, 1916.*

Early Exploration of the Area

The first exploration was by Walter McOuat[3] who in 1872 made a reconnaissance survey of the Blanche river from lake Timiskaming to Round lake.

W. G. Miller,[4] Provincial Geologist, in 1900 described a portion of the area. In his report the geology along the Blanche in McElroy and Catharine townships

[1] Map No. 23 a, accompanying Part II, Vol. XXIV, Rep. Ont. Bur. Mines, 1914.
[2] Map No. 25 d, Ont. Bur. Mines.
[3] Report on an Examination of the Country between Lakes Timiskaming and Abitibi, Report of Progress, Geol. Sur. Can., pp. 112-135, 1872-73.
[4] Lake Timiskaming to the Height of Land, 11th Report, Ont. Bur. Mines, 1902, pp. 214-230.

is described. He also mentions prospecting for gold on a 4 or 5-foot quartz vein in the hill west of the lower end of a portage which is now shown in lot 9, concession III, Catharine township.

In 1904, after the discovery of Cobalt, W. A. Parks[5] of the University of Toronto made a geological survey of this portion of the country. Parks remarks that the high hills along the Blanche, in the township of Catharine, are well worth prospecting for gold.

In 1908 and 1909, M. E. Wilson examined the Larder Lake gold area, which is located to the east of Boston creek. The geological map accompanying his report[6] joins the east side of the Boston Creek sheet.

Topography

The area in general has an elevation varying from 700 to 1,050 feet above sea level. Boston Creek station has an elevation of 920 feet. While the difference in elevation is seldom more than 200 feet, the country is somewhat rugged and broken, particularly in the vicinity of Boston Creek station and along the north branch of the Blanche river in McElroy and Catharine townships.

The country is situated south of the continental divide, and is drained by two branches of the Blanche river and their tributaries, which flow southward into lake Timiskaming.

The magnetic declination is about 8 to 9 degrees west of north.

General Geology

The rocks are all pre-Cambrian in age, the nearest younger formation being an exposure of Niagara limestone about ten miles to the south in lot 10, concession IV, Evanturel township. The rocks of the area may be classified as follows:

PLEISTOCENE		
Glacial and recent:—		Boulder clay, sand and gravel.
PRE-CAMBRIAN		
Keweenawan:—		Quartz diabase dikes.
	(INTRUSIVE CONTACT)	
Algoman:—		Feldspar porphyry and quartz porphyry, hornblende and biotite granite, and syenite.
	(INTRUSIVE CONTACT)	
Timiskamian (?):—		Conglomerate, greywacké and slate.
	(UNCONFORMITY?)	
Keewatin:—		Grey schist (volcanic fragmental rocks and iron formation). Ellipsoidal, amygdaloidal and spherulitic lavas, agglomerate, tuff, iron formation, serpentine, diabase and felsite. (These rocks are in part altered to hornblende and chlorite schists.)

[5] The Geology of a District from Lake Timiskaming Northward. Summary Report of the Geol. Sur. Can., pp. 198-225, 1904.

[6] Geology and Economic Resources of Larder Lake District, Mem. No. 17-E, Geol. Sur. Can., 1912.

Keewatin

The Keewatin rocks have the widest distribution, and are important since they contain gold-bearing veins. They consist chiefly of greenstones with some volcanic fragmental rocks and iron formation. A band of clastic sediments is mapped as grey schist. The original constituents are so entirely altered that many exposures may be spoken of as serpentine, hornblende and chlorite rocks. Cutting the greenstones is a felsitic rock which may be post-Keewatin in age.

Greenstones: The greenstones are fine-grained, and consist of altered basic volcanics which are sometimes schistose, but more often massive. They commonly show the amygdaloidal and ellipsoidal structure, and more rarely the spherulitic, indicating their volcanic origin. The spherulitic structure, which is rare in basic rocks, has not been noted before in this section of Ontario. What may be the spherulitic structure in greenstone was reported on the north shore of Doig lake in the northwest corner of Lebel township.[7] A similar structure was also seen under the microscope in an acid rock, a rhyolite, from lot 6, concession III, Beatty township.[8] In this area, spherulitic greenstones are beautifully developed on a bare hill on claim L 1878, Boston township. The varioles, which are rounded and white-weathering, vary in size from minute pea-like form to those about two inches in diameter, and constitute a large part of the rock. Under the microscope the varioles consist of coarse radiating flakes of chlorite, feldspar, epidote and probably quartz in a fine groundmass of the same material, and actinolite. Throughout the whole rock are pyrrhotite grains and numerous black ferruginous specks. The rock is probably an altered basalt.

The pillow lava flows constitute the main portion of the greenstone. They are interbedded with much non-pillow greenstones, which have a diabasic texture at times, and some tuff, agglomerate and slate which point to a subaqueous origin. The nearly complete alteration of the greenstones, with the retention of their original ellipsoidal structure, is, according to Leith and Van Hise, due to a metasomatic rather than a dynamic change. Under the microscope the original minerals in the greenstones are hornblende, quartz, magnetite and plagioclase, the altered plagioclase laths suggesting a basaltic or diabasic texture. The secondary minerals are calcite, hornblende, chlorite, sericite and quartz. The altered greenstone in places may be spoken of as hornblende or chlorite schist.

Volcanic fragmental rocks: Tuff and agglomerate are prominent, particularly in the northwest corner of Catharine township. They are, in places, interbedded with the basic volcanics. They are somewhat similar to the grey schists described below, but are too much intermingled with the greenstones to map separately.

Iron formation: Iron formation, consisting of interbanded silica, black slate and magnetite, occurs in the greenstone in the north part of Boston township. The iron range has been described in detail by W. G. Miller[9] and by the writers.[10]

[7] Kirkland Lake and Swastika Gold Area, by A. G. Burrows and P. E. Hopkins. Report, Ont. Bur. Mines, Vol. 23, Pt. 2, 1914, p. 4.

[8] Beatty-Munro Gold Area, by P. E. Hopkins. Report, Ont. Bur. Mines, Vol. 24, Pt. 1 1915, p. 176.

[9] Boston Township Iron Ranges, 14th Rep., Ont. Bur. Mines.

[10] Kirkland Lake and Swastika Gold Areas, 23rd Rep., Pt. II, Ont. Bur. Mines.

Keewatin volcanic fragmental, intruded by narrow reddish feldspar porphyry dikes, southeast of Boston Creek station.

Volcanic fragmental rock, one-quarter of a mile east of Boston Creek station.

Serpentine: The trail on claim L 4902, Boston township, passes over an exposure of serpentine. A thin section of the rock was examined microscopically and found to consist of about 60 per cent. of serpentine and 40 per cent. of calcite. Numerous magnetite grains and a little pyrite are scattered through the rock.

Grey schist: A belt of banded, greyish-green schist resembling an altered sediment has been differentiated on the map. The series, which occurs on the periphery of a granite and syenite mass, is about one mile in width and ten miles in length, passing in a semi-circular shape from lot 12, concession II, Catharine, through Boston Creek station to Round lake. The rocks may be best seen in the vicinity of Boston Creek station, where deep railway cuts have been made. The schist approaches a vertical attitude with a strike parallel to the periphery of the granite. A great portion of the series consists of narrow alternating bands of rusty carbonate (including some magnetite and pyrite bands) and slate. Ash rocks, with bomb-like inclusions, are common. Some thin sections represent greywacké and quartzite, while one is clearly an altered porphyry. The whole series is greatly metamorphosed by the large granite mass, and is cut by narrow porphyry, lamprophyre and other dikes. In the vicinity of Round lake much altered diabase and green chloritic dikes are intruded into the banded schist. At mileage 153 on the Timiskaming and Northern Ontario railway two or three narrow bands of pyrite occur in the grey schist. The series was probably laid down conformably with the Keewatin pillow lavas.

Felsite: In the southwest part of McElroy township, and running northwestward across Boston township, are small areas of a white-weathering, felsitic-looking rock which may be post-Keewatin in age. Owing to the complex manner in which the felsite or rhyolite and greenstones have been intermingled, it would be difficult to map the outcrops on a small scale map. The word "felsite" is written on the map across the main areas. The rock is fine-grained, grey, green or pink in colour, and resembles chert. Under the microscope one-half the thin section is seen to consist of phenocrysts, which are rather small, and uniform in size. The phenocrysts consist of albite, partly altered to sericite, an occasional quartz grain, and some hornblende and chlorite masses. The fine-grained groundmass is dominantly quartz, with feldspar, chlorite, sericite, epidote and numerous grains of magnetite and pyrite. Narrow quartz veins are sometimes present in the rock.

Timiskamian

A few small, isolated patches of conglomerate schist, slate and greywacké, standing in a vertical attitude, occur along the Larder Lake road in Boston and McElroy townships. The rocks are similar to the sediments classed as Timiskamian on the map of the Kirkland Lake and Swastika gold areas. The pebbles of the conglomerate, which are elliptical in outline, consist largely of greenstone and felsite and some Iron formation. A grey magnesian limestone occurs both as pebbles and matrix in the conglomerate in McElroy township about a mile east of the three-mile post on the west boundary.

Algoman

These rocks include batholith and stocks of granite and syenite, and dikes of feldspar porphyry, quartz porphyry and lamprophyre. They are massive, fresh-looking, and are probably Algoman in age, since similar granite in Boston and Lebel townships to the north was found cutting the Timiskamian series.

Granite and Syenite: A batholith of red, biotite granite occupies nearly all of Pacaud township, and extends to the south and west beyond the township boundaries. In the southwest part of the township garnets are present, while in other parts the granite may be said to change into a quartz syenite. The rock is massive, except near the contact with the Keewatin, where it occasionally takes on a gneissoid structure. Near the contact with the greenstone, just south of mileage 153, the granite is intruded by numerous parallel felsitic dikes which give the rock a banded structure. It is cut by quartz veins, and by pegmatite and other dikes representing various differentiation facies of the magma. The rock in the south part of lot 9, concession VI, Pacaud, is a light grey, medium

Granite, with fragments of Keewatin greenstone, and narrow dikes (apophyses of the granite) cutting the granite and fragments of greenstone on Authier claim, Boston township.

grained, biotite granite. Under the microscope microcline is seen showing the gridiron structure, albite partly altered to sericite, biotite altered partly to hornblende and chlorite, quartz and calcite.

A reddish syenite outcrops in the west part of Boston township, being part of the large syenite boss-like mass occupying most of Otto township.

A small stock of reddish biotite and hornblende granite intrudes the greenstones in McElroy township. Gold and a telluride have been found in this granite in a pegmatitic quartz vein which is probably a part of the granite magma.

Other small, irregular, granitic dikes cut the greenstones and felsitic rocks. Gold was seen in quartz veins in these small granite dikes on claim L 5165 and L 5133, Boston township.

Feldspar Porphyry: Numerous intrusions of massive red and grey feldspar porphyry occur over the whole area. They appear as narrow dikes up to thirty feet or more in width, and probably represent apophyses from the granite masses. The phenocrysts usually consist of albite, often showing a zonal structure, an occasional rounded quartz grain, and blades of biotite in a microcrystalline groundmass of quartz, feldspar, chlorite and calcite. Fine grains of magnetite and pyrite, and crystals of apatite are often present. A feldspar porphyry on claim L 2000, Boston township, and in other parts of that vicinity, contains white feldspar phenocrysts up to one inch across, which show beautiful zonal structure in the hand specimen. Some porphyry dikes in the southwest part of Boston township contain many prominent quartz phenocrysts, and thus resemble the quartz porphyry at Porcupine. In other parts the rock may be called a felsite. The acid dikes are usually cut by minute veinlets of quartz, some of which carry gold. Small, irregular fragments of red feldspar porphyry are also, at times, present in auriferous quartz veins.

Lamprophyre: A few narrow lamprophyre dikes cut the greenstones and grey schist, but these are too small to map. They may be seen on the south part of lot 3, concession VI, Pacaud township, and at about mileage 154.3 along the railway. In the Kirkland Lake area the lamprophyre cuts the Timiskaming sediments, but is older than the feldspar porphyry. A lamprophyre dike that intrudes the Algoman granite can be observed in a rock-cut about half a mile north of Mindoka.

Keweenawan

Quartz diabase dikes are rare in this area; however, they were noted cutting the greenstones and Timiskamian (?) sediments. To the northwest, in Teck township, the diabase was seen to cut the red feldspar porphyry. These dikes are classed as Keweenawan, since they are fresh-looking and resemble the diabase at Cobalt. A thin section of a sample taken immediately south of M.R. 15, Boston township, shows labradorite laths, partly altered to saussurite and sericite, augite partly altered to hornblende and chlorite with a little quartz, biotite, magnetite and intergrowths of quartz and feldspar.

Glacial and Recent

The region has been heavily glaciated, the ice having moved in a general S. 20° E. direction, astronomic.

The area lies at the northern edge of a tract of farming land, which extends from Haileybury to Round lake, and is covered in places with stratified clays, sand and gravels. At Boston Creek station one can see the vertical section of a morainic deposit which has been cut into by Boston creek. The central part of McElroy township to the east of the Blanche river is one vast area of sand, representing probably large terminal moraines and outwash plains.

Economic Products

Gold

Gold, the chief mineral sought for in the area at the present time, occurs usually native, but occasionally combined with tellurium in quartz veins and

veinlets in the Keewatin greenstone and later intrusions of granite and porphyry. The veins, which have a varying strike and dip, are well mineralized with varying quantities of pyrite and molybdenite, and sometimes with chalcopyrite, galena, specular hematite, bismuthinite, gold and a telluride. The gangue consists largely of quartz of several generations, with considerable calcite and chlorite. The gold is found along the dark streaks of chlorite and calcite.

There are various types of gold deposits, viz.:

(*a*) Fissure quartz veins in the greenstone and porphyry, with well-defined walls. Examples, Miller-Independence, McRae and Authier.

(*b*) Replacement veins. The country rock, including altered greenstone and porphyry, has been brecciated and partly replaced by vein-forming solutions of quartz of several generations, and by calcite and other carbonates. Example, the Kenzie vein on the R. A. P. property.

(*c*) A stockwork in granite and porphyry. Examples, Charest claim (McElroy township), Authier (L 4737) and Papassimakes (L 5133).

The chief deposits will be described later in the report when dealing with the gold claims.

Pyrite

Pyrite occurs in two narrow bands, and disseminated through the grey schist at mileage 153 on the railway in Pacaud township. About 100 feet east of the 153-mile post, two shallow pits were sunk several years ago, and at present one can see a little pyrite on the dumps, but the deposit "in place" is covered with débris. In the deep railway-cut there are two bands of pyrite 10 and 20 inches wide respectively which will carry about 35 per cent. of sulphur; samples from each band were found to contain no gold values. The deposits did not appear to be large enough to work, although wider ore bodies might be revealed by further trenching. Iron pyrites is used in the manufacture of sulphuric acid.

Copper

Several calcite veins with some quartz, and carrying copper pyrites, occur in the vicinity of the Blanche river in the south part of McElroy township. The Jean Petit copper property, W.R. 97, in this vicinity, has been referred to by W. G. Miller and W. A. Parks. Considerable work has been done on the calcite veins, but as far as known no copper has been shipped. It is reported that gold and silver values occur with the copper.

The Dane Mining Company has done considerable prospecting and shipped some copper ore from Teck and Lebel, adjacent townships to the north and northwest.

Iron

The isolated exposures of iron formation along the Larder Lake road in Boston township represent the southern portion of the Boston township iron range. The formation consists of interbanded silica and magnetite, with some black slate. Numerous shallow test pits were sunk in 1902, but the iron proved to be too low grade to be workable at that time. The iron formation is, in places, intruded by quartz veins, some of which carry gold.

Building Stone

The red and grey granite and syenite along portions of the railway in Pacaud township is serviceable for building purposes. The fine station at Matheson is constructed of stone taken from along the railway immediately to the north and south of Mindoka.

Timber and Agriculture

In general the trees are small, and consist of spruce, jack pine, poplar, birch and cedar. A few white pine, three and one-half feet in diameter, to the south-east of Smith lake, have escaped an old fire which swept most of the area. Large charred stubs of pine in various parts of the area are relics of the same fire. Other parts have been recently burned.

Many farms have been located on the scattered clay areas of Pacaud township, while the greater part of the remaining area is unsuitable for agriculture by reason of rock, sand or swamp.

Water Powers

No hydro-electric power is used as yet in the area, mining being in the early prospecting stage.

The transmission line of the Long Lake Power Company runs from Charlton along the west side of the area and furnishes energy to the Tough-Oakes mine at Kirkland lake.

K. Farah, of Englehart, has applied for a waterpower on the northwest branch of the Blanche river in lot 12, concession IV, Pacaud township. On August 12th, 1914, the discharge of the river at this point was 350 cubic feet per second. The 61-foot falls is expected to develop 405 horsepower. Immediately to the north in concession V, is a 36-foot falls which could be utilized to develop an additional 240 horse power.

Messrs. Hotchkin and Grover of Haileybury expect to develop a minimum of 2,000 horse power at High falls on the north branch of the Blanche river in lot 11, concession IV, Marter township, where a total operating head of 138 feet is avilable. The discharge of the river on May 6th 1915 was 552 cubic feet per second. The transmission line would follow approximately the railway to Boston creek and Kirkland lake.

It is the intention of the Northern Ontario Light and Power Company to extend their lines during 1916 from Cobalt to serve both Boston creek and Kirkland lake.

Origin of the Gold Deposits

As pointed out by W. G. Miller and C. W. Knight in a paper called "Metallogenetic Epochs in the Pre-Cambrian of Ontario,"[11] most of the gold deposits of Ontario belong to the Algoman epoch. The gold deposits of Boston creek supply another example of gold being derived from acid intrusives of Algoman age. The granite, syenite and feldspar porphyry exposed in this area by erosion are probably different facies of a plutonic rock which underlies the whole area. The gold generally occurs near these acid rocks. The presence of a number of gold-

[11] Rep., Ont. Bur. Mines, Vol. XXIV, Part I, 1915, pp. 243-248.

bearing veins along the contact of the intrusive porphyry and older rocks at Boston creek, as in many other parts of central Canada, and the frequent occurrence of auriferous quartz veinlets in the porphyry and granite, suggest the relationship between the intrusives and the veins. The relationship is more clearly shown in this area by the occurrence of gold in a pegmatitic vein in the granite on the Charest claim, McElroy township.

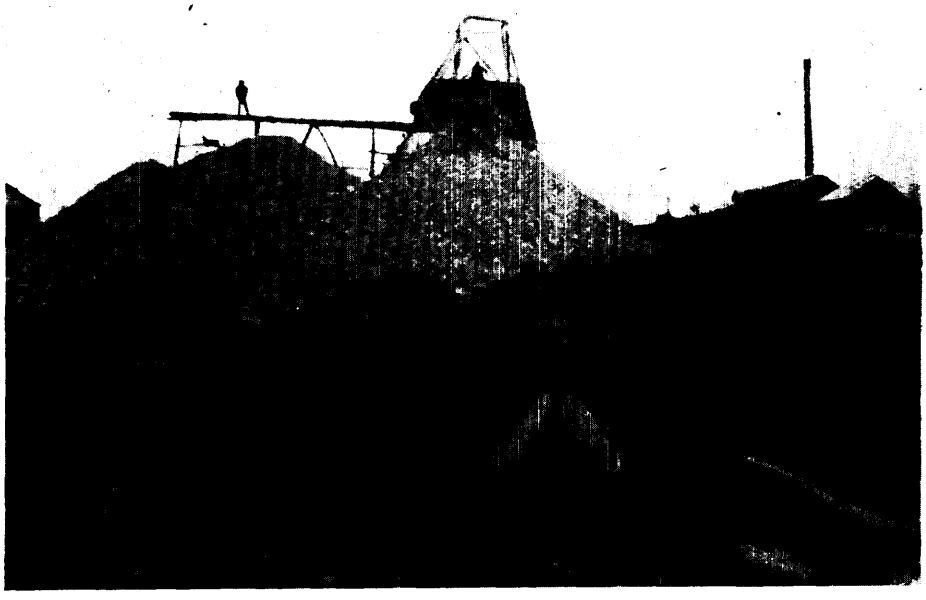
The deposits are in part due to the replacement of the country rock by mineral solution.

Some minerals which characterize deposits that are formed at high temperatures are found in the veins at Boston creek. Actinolite was noted in a thin section of material from the Kenzie vein, and specularite has been frequently observed in other veins. Other minerals formed at high temperature, such as pyroxene, apatite and tourmaline, have not been noted. It is probable that the deposits were formed at great depth, but not at extremely high temperature.

Description of the Gold Prospects

R. A. P. Mining Company

The R. A. P. Prospecting, Developing and Mining Syndicate owns a number of mining claims in the area, the principal ones being L 3665 and L 5163 in the south central part of Boston township. Some work was done on these claims



Shaft and power plant, R. A. P. Mining Co. *May, 1916.*

in 1914 by the La Rose Mining Company. Since May, 1915, Mr. John Papassimakes has had a number of men engaged in opening what is known as the "Kenzie" vein, which occurs in a massive pillow lava. The vein, which has been stripped

for about 400 feet, strikes 30 degrees north of east, astronomic, and dips from 60 to 70 degrees to the south. It varies from several inches up to five feet in width, with good breaking walls on either side. Spectacular gold showings were obtained from a 28-foot shaft on the western end of the vein and finely disseminated gold can be seen in many samples on the dump.

When the property was visited in May 1916, the easterly inclined shaft had reached a depth of 135 feet, and 230 feet of drifting on the vein had been done on the 100-foot level. Development has shown the ore to occur in shoots in the vein. The vein material consists of quartz of several generations, silicified rock, reddish calcite, and brecciated and partly replaced masses of reddish feldspar porphyry. The occurrence of feldspar porphyry in various parts of the workings suggests that originally the greenstone was intruded by a narrow feldspar porphyry dike, that at a later period was greatly brecciated, and impregnated with vein-forming solutions which carried the gold and other minerals. The gold occurs with a very fine-grained greenish quartz, which has the character of a replacement deposit, while the green colour is due to minute inclusions of chlorite. Iron pyrites is finely disseminated in the vein, and copper pyrites, molybdenite and galena occur in minor quantity.

Thin sections of the ore show the gold to be closely associated with the sulphides in chlorite and calcite seams near the foot wall part of the vein, where there is a narrow band of fine grained greenish quartz. Certain sections of the vein run as high as $25 or $30 in gold to the ton across five feet.

The property is equipped with a small plant, including a 60 h.p. boiler, 2-drill compressor and hoist.

On the east side of claim L 2631, which lies immediately northeast of that on which the main shaft is sunk, there is an irregular band of mineralized schist with quartz, about one foot wide, which contains visible gold. The showing occurs where the greenstone is intruded by a dike of feldspar porphyry, and near the contact.

About one mile to the northeast, on claim L 5165, there is a red medium grained mica granite intruding the Keewatin. Cutting the granite are several narrow white quartz veins, some of which carry molybdenite and a few specks of native gold.

Currie

The Currie unsurveyed claim, L 5037, is situated about one-half mile northeast of the R. A. P. property in Boston township. In the west and northwest parts of the claim are rusty schist bands heavily mineralized with iron pyrites, and cut by quartz stringers. No visible gold could be seen in place, but gold colours can be panned from the sulphides. A grab sample showing cubes of pyrite gave $2.40 in gold to the ton, while samples across two feet and three feet seven inches gave $1.60 and 60 cents respectively in gold to the ton. Some trenching has been done.

Miller-Independence

This property is situated on the south half of lot 1 in the sixth concession of Pacaud. Gold was discovered on the lot by a prospector, Mr. Joseph McDonough, in July 1915. The vein has been traced on the property for about 600 feet in an east and west direction, and for several hundred feet easterly into Catharine

township. It is narrow, averaging about a foot in width, and has a low dip to the north, usually about 20° or less, at one place being almost horizontal. The vein material is milky white quartz, and the mineralization is more or less concentrated toward the foot wall side of the vein. Telluride, copper pyrites, pyrite, specular iron ore and galena are observed in the quartz. Native gold occurs frequently with the telluride and other minerals in a net-like arrangement in the quartz along the foot wall. There are probably several tellurides, but so far only one, a bismuth telluride, containing some selenium, has been recognized. This telluride of a brilliant grey colour appears to occur abundantly with the gold.

The country rock is mainly fine-grained pillow lava, associated with which is a coarsely grained basic rock of a hornblendic type. Along the vein there is a dike of grey feldspar porphyry which at two places is two feet wide on the hanging

Power plant and mill at Miller-Independence property. *May, 1916.*

wall side of the vein. The porphyry was also observed on the foot wall side. It contains much calcite and other carbonates, as well as disseminated iron pyrites, and is cut by veinlets of quartz.

The vein has been prospected by means of a number of trenches and pits, from which some high-grade ore has been bagged. A shaft was being sunk to the north of the vein. The property is equipped with a small plant, including boiler, compressor, hoist, and a Nissen stamp mill; and a small oil flotation plant was being constructed.

McRae

The McRae claim is the northeast quarter of the north half of lot 2, concession VI, Pacaud township. The vein has a general magnetic north and south strike, with a dip of about 45° to the east. Fine gold can be seen in a number of places, particularly on the hanging wall part of the milky white quartz vein, which is about one foot in width.

Small steam plant on McRae property. *May, 1916.*

Gold bearing quartz vein, dipping 20° N. The man is standing on the hanging wall side of vein, while the foot wall is shown in the foreground, Connell-McDonough claim, Catharine township.

The country rock is pillow lava and massive greenstone showing a diabasic texture, while the wall rock is considerably altered in places next the vein. A shaft is being sunk on the vein to the 100-foot level. Exposed in the shaft, the vein has a somewhat banded structure, showing streaks of dark quartz, with considerable iron pyrite, some films of molybdenite, and dark grey calcite.

The property was being prospected by the Crown Reserve Mining Company in May 1916.

Connell-McDonough

This property is the south half of lot 12, concession VI, Catharine township. The vein on the Miller-Independence which is being prospected can be traced easterly to the Connell-McDonough claim, where there has been considerable trenching along the strike of the vein. Native gold can be observed at several places along the foot wall of the vein.

Cullen-Renaud

This group of claims is situated in the northeast corner of Pacaud township. Native gold has been reported to occur in several veins which outcrop on the surface. The veins which outcrop on the McRae and Miller-Independence properties, if continued to depth on their indicated dips, would pass into this property at some depth.

Prospector at his discovery of native gold in veinlets in the granite, Authier claim, southeast part of Boston township.

Authier-Charlebois

Mining claims L 4737 and L 5025 are situated in the southeast part of Boston township, just to the north of the McRae property. The quartz veins in the greenstone are similar to the McRae vein, being narrow and dipping about

45° N. Native gold has been discovered in some of them, along with pyrite and a grey mineral bismuthinite.

Toward the north part of the property is a small area of fine-grained mica granite which intrudes the greenstone. At one place near the contact there is a quartz vein one foot wide in the granite, on which a shallow pit has been sunk. Molybdenite, pyrite and bismuthinite are disseminated in parts of the quartz vein, and visible gold was reported to have been seen. A sample across eleven inches, taken a few feet from the pit, gave $4.80 in gold. Northwest of this discovery, beyond a ravine, the granite is intersected by numerous quartz veinlets, some of which are several inches wide. In some of the narrow joint-like cracks native gold was observed, along with a grey mineral which gave reactions for tellurium and bismuth and is probably tetradymite. There is also considerable iron pyrites in the granite along some of the veinlets.

Charest

The Charest unsurveyed claim, L 5305, is situated in the southwest quarter of McElroy township. As shown on the map, the claim is on a small stock of massive, coarse-grained, flesh-coloured hornblende and biotite granite. A quartz vein averaging about one inch in width, and 300 feet long, strikes 30 degrees north of west across the granite. Considerable fine gold, pyrite, chalcopyrite, and a grey mineral which proved to be a telluride, were noticed in different parts of the vein. A few pieces of quartz from the vein gave, on assay, $8.80 in gold to the ton. Other veins on the property contain molybdenite and specular hematite. Some of the veins contain coarse feldspar and are pegmatitic in character, while many of the narrow veins represent the filling of joint cracks. The occurrence of gold in the pegmatitic vein is important, since it strongly points to the formation of the gold-bearing quartz veins following the pegmatitic veins and representing part of the granite intrusion.

Conclusion and Acknowledgments

The geology and mineralogy of the Boston Creek area is, in a general way, similar to that of the adjoining Swastika, Kirkland Lake and Larder Lake areas. Gold is known to be widely distributed over all the areas. No bullion has, as yet, been shipped from Boston creek. The Tough-Oakes, Swastika, Lucky Cross, La Mine D'Or Huronia and Goldfields Limited properties, which are from 12 to 15 miles from Boston Creek station, have from 1912 to the end of 1915, yielded gold valued at $779,715. Most of this production was from the Tough-Oakes mine. In Boston creek the prospecting, as yet, has been largely confined to the surface, the deepest shaft being 135 feet (May, 1916). Prospecting is aided by the excellent transportation facilities. In prospecting the area it seems a good rule to trench in the old rocks near the porphyry dikes and small granite areas.

In conclusion, the writers wish to express their indebtedness to several of the men in charge of mining and prospecting operations, particularly to J. Papassimakes of the R. A. P. property. The assays were made and some minerals identified by W. K. McNeill and T. E. Rothwell, of the Provincial Assay Office. The accompanying map was drawn by P. A. Jackson.

GOODFISH LAKE GOLD AREA

By

A. G. BURROWS and P. E. HOPKINS

Introduction

Goodfish lake, 1,025 feet above sea level, is situated two miles northeast of Kirkland lake in the Larder Lake Mining Division, near the intersections of the four townships, Teck, Bernhardt, Morrisette and Lebel. The area is three miles south of the height of land which separates the Hudson Bay and St. Lawrence River waters. Hills seldom rise more than 100 feet above the adjacent valleys. A wagon road nine miles in length connects Goodfish lake with Swastika, a station on the Timiskaming and Northern Ontario railway, 390 miles north of Toronto.

Gold was first found on the Costello claim, L 2194, in the summer of 1912, shortly after the discovery of gold on the Tough-Oakes mine, two and one-half miles to the south. Reference is made to gold on the Costello claim in the report on the Kirkland Lake and Swastika gold areas,[1] and part of the geology is included on the coloured map accompanying that report.

During 1915 considerable prospecting was done around the lake on the Costello, Martin, Brennan, Gibson, Potvin, Papassimakes and other claims. All have ceased work at present (April, 1916,) except the La Belle Kirkland mines, who are continuing with underground mining on the Gibson-Potvin claims in the northeast corner of Teck township.

Geology

Keewatin

The Keewatin is the oldest and most dominant of the rocks, which are all pre-Cambrian in age. The Keewatin rocks consist of pillow and amygdaloidal lavas (meta basalts) and altered diabases in about equal volume. Some of the rocks are quite massive, while others are very schistose and rusty, striking easterly and dipping vertically. The original constituents are largely altered, mainly to calcite, chlorite and sericite, and often the rock is so greatly metamorphosed that there is no clue to its original nature. The fine-grained greenstone on the southwest corner of the Costello claim, L 2194, Morrisette township, shows under the microscope rounded and angular quartz grains, some with corroded edges, in a groundmass of calcite, chlorite, sericite, altered feldspar, leucoxene and apatite. This rock is identical to the rock which shows large "eyes" of quartz and occurs with the pillow lava flows in Porcupine, and is probably a more acid rock than basalt.

Quartz-Feldspar Porphyry

Cutting these older rocks are dikes, stocks and flow-like masses of granite porphyry (quartz-feldspar porphyry or rhyolite porphyry). The porphyry has a grey colour, and a whitish weathering surface in which white quartz phenocrysts

[1] Ont. Bur. Mines, Vol. XXIII, Pt. 2, 1914, p. 31.

a quarter of an inch across are quite conspicuous. Under the microscope the rock is holocrystalline. The phenocrysts consist of about 5 to 10 per cent. of quartz and 50 per cent. of albite-oligoclase partly altered to sericite. The groundmass is felsitic, consisting of sericite, plagioclase, quartz, chlorite, pyrite and iron oxide. The porphyry is somewhat schistose, and is similar to certain porphyries described in Porcupine and many other parts of northern Ontario.

In the Kirkland Lake and Swastika report[2] the quartz-feldspar porphyry was classed as Keewatin on account of the fact that a conglomerate, on the north shore of Gami lake, classed as "Timiskaming," was found to contain fragments of quartz-feldspar porphyry quite similar to the porphyry which occurs near at hand "in place." There is a possibility that this small isolated area of conglomerate is of later age than "Timiskaming," in which case the quartz-feldspar porphyry might be of Algoman age, similar to the feldspar porphyry around the Tough-Oakes mine.

The age of the quartz porphyries in northern Ontario is usually difficult to determine, that is, whether of Keewatin or later age. They may be in part connected with the acid flows interbedded with the Keewatin pillow lavas, or they may be of Laurentian age. In any case some porphyries seem to have yielded most of the acid pebbles for the Timiskaming conglomerates.

Timiskamian Series

The conglomerate and slate in the southeast corner of the accompanying map is the northern extremity of a large volume of Timiskamian sediments which have been described fully in the report on the Kirkland Lake and Swastika gold areas.[3] The sediments were laid down unconformably on the eroded Keewatin surface. An unconformity can be seen on claim L 2796, where the overlying conglomerate contains fragments of the amygdaloidal basalt and diabase similar to the underlying Keewatin.

Economic Geology

The rocks of the area are mostly massive and schistose greenstones, cut by small irregular masses of schistose quartz-feldspar porphyry. Gold, the chief mineral sought for, occurs in narrow quartz veins and replacement deposits along the contact of porphyry with other rocks. The veins or stringers are generally an inch or less in thickness, but there may be a series of them forming a lode deposit. Often two or three parallel slip planes coated with quartz and a thin film of molybdenite may form the ore body. The large amounts of molybdenite and pyrite give the deposits a dark and rusty appearance. Visible gold, in a state of fine division, occurs in many parts of the area. A telluride has been reported to occur in Morrissette township, but no such mineral has been identified in the laboratory of the Bureau of Mines. Calcite and other carbonates occur with the quartz.

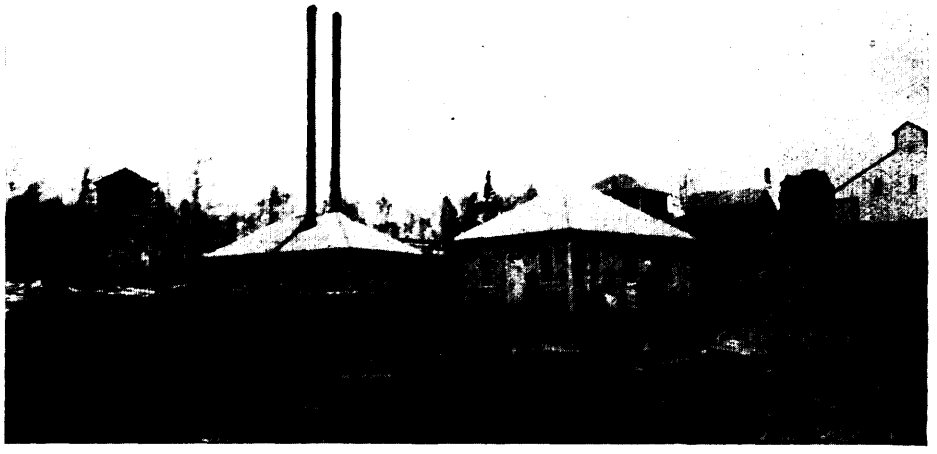
The quartz-feldspar porphyry appears in some way to have influenced the gold deposition as similar porphyries have done in Porcupine; and it seems also to have been the source of the gold-bearing solutions. If the porphyry is the source of the ores and is pre-Timiskamian in age, then the gold deposition of

[2] Ont. Bur. Mines, Vol. XXIII, Pt. 2, 1914, p. 10. [3] Ibid, pp. 9 and 10.

Goodfish lake is of an older type (Keewatin or Laurentian) than the Kirkland Lake gold-telluride deposits, which are clearly connected with the Algoman intrusions of feldspar porphyry.

The cessation of work by many properties would suggest that many of the deposits are low grade. La Belle Kirkland Mines, the only property being worked (May 1916) has blocked out considerable ore.

La Belle Kirkland: La Belle Kirkland Mines Limited is operating a group of claims to the south of Goodfish lake. Of these claims the most important is L 1751, on which the company had sunk a shaft to the 300-foot level (May, 1916). The ore deposit occurs along the contact of quartz porphyry and basalt. The porphyry lies to the north, and forms the hanging wall of the deposit, which occurs in the altered basalt. The shaft, which inclines 60° N. for 80 feet, and



La Belle Kirkland Mines, showing a large erratic of basalt on the right.
May, 1916.

70° N. below this level, is on the dip of the ore body, which is also approximately the angle of contact of the porphyry and basalt. The basalt near the contact is greatly altered to a greyish rock high in silica, calcite and other carbonates. The altered rock has the following composition: silica, 46.94 per cent.; ferric oxide, 5.60; ferrous oxide, 5.16; alumina, 13.94; lime, 9.31; magnesia, 1.19; soda, 2.12; potash, 2.48; water, 2.15; carbon dioxide, 11.43. In this altered basalt area there are streaks or bands of blackish material which form the higher grade portion of the deposit. These streaks contain films of molybdenite, to which the dark colour is due, and abundant iron pyrite, quartz and calcite, while visible gold is occasionally seen. A dark band near the foot wall was persistent in the shaft, while other bands toward the hanging wall are more lenticular, but have similar characteristics to the foot-wall streak. The silicified material between the streaks or bands carries low values in gold, but the values obtained in the high-grade streaks, which vary from a part of an inch to a foot in width, have indicated that the deposit is workable over a considerable width. The management is at present continuing the sinking of the shaft and drifting and crosscutting at several levels to determine the size of the ore body.

The narrow high-grade streaks or bands are reported to carry from $20 to $150 per ton in gold, while a probable value of from $15 to $18 per ton is given for a width of 7 feet to 10 feet, for some of the ore.

The deposit is evidently a replacement of the basalt near the contact with the porphyry. There is no evidence of the filling of open fissures with milky white quartz. Slickensides surfaces in the material of the streaks indicate some faulting along the dip of the deposit.

The equipment consists of two 60 h.p. Robb-Mumford boilers, a 4-drill compressor, and hoist. Timber from the company's properties is at present used for fuel. Frank Loring is manager, and Ernest Loring superintendent of the mine.

Costello: Gold was found on the Costello claim, L 2194 and L 2202, Morrissette township, in 1912. The dominant rock is a Keewatin greenstone, which has been intruded by small irregular masses of a quartz-feldspar porphyry. The basalt has been greatly altered to rusty-weathering carbonate. The gold occurs in rusty quartz and calcite veinlets, which are more or less irregularly distributed in a mineralized zone as shown on the map. Considerable trenching has been done transverse to the strike, which shows the gold-bearing zone to extend for 400 yards or more. A shaft was sunk in 1915 on the west part of the zone, and while some gold was found near the surface, the work was discontinued. The property is owned by the Goodfish Lake Mines, Limited.

Martin (L 2233): This claim is situated north of the Costello (L 2194). A gold-bearing zone occurs along the contact of the quartz-feldspar porphyry and the basalt. It dips about 65° N. and strikes N. 30° E., and has been traced by trenching to the Brennan claim, which lies to the east. On the line between the claims the vein four inches in width is exposed, while along the contact the porphyry and schist are greatly stained by iron oxide, an alteration product of iron pyrites. An inclined shaft was sunk on the Martin claim to a depth of 20 feet, but at the time of the visit was filled with water. It is reported, however, that the south wall of the shaft showed a mineralization over widths of four to six feet, several narrow irregular quartz veins being exposed with promising assays in gold, while the north wall of the shaft showed neither so much quartz nor such good values.

Brennan (L. 2603): An inclined shaft 18 feet in depth was sunk on this claim. The shaft is probably on the extension of the vein which occurs on the Martin. The vein material between the porphyry and basalt has a width in one place of 15 inches, and consists of quartz, calcite, molybdenite and pyrite.

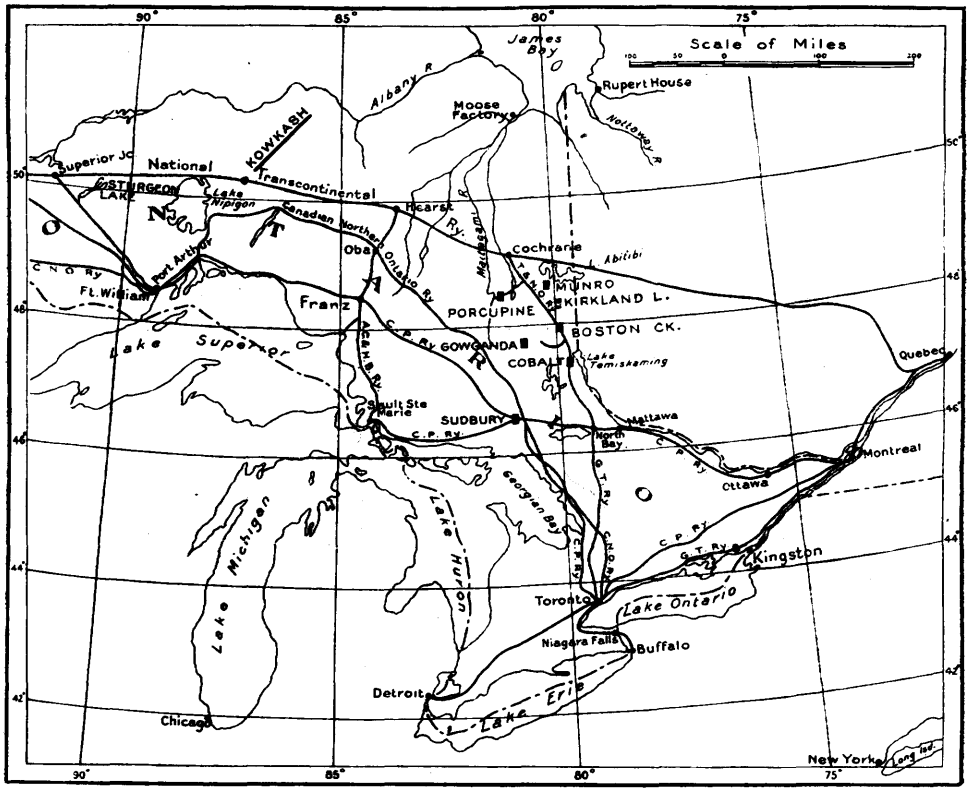
Brennan-Bowes Group: During the fall of 1915 the Dominion Reduction Company had a working option on a group of claims immediately to the east of the Costello group. A large amount of trenching was done across contacts of porphyry and basalt, while two shafts were sunk to a moderate depth at supposedly favourable locations. A shaft on claim L 2614 is on the contact of the porphyry and basalt, with the basalt forming the north or hanging wall. This condition is the opposite to that at the La Belle Kirkland mine, where the prophyry forms the north or hanging wall. Low gold values were obtained in the vein material from this shaft, but these were not sufficient to indicate a workable deposit.

KOWKASH GOLD AREA

By P. E. HOPKINS

Introduction

In accordance with instructions received from Thos. W. Gibson, Deputy Minister of Mines, the writer left Toronto on September 6th, 1915, and spent six days in making a preliminary investigation of the recent gold discovery near Kowkash, a station 297 miles west of Cochrane on the National Transcontinental railway. A preliminary report[1] was published in the Canadian Mining Journal, Toronto, and a map[2] of part of Thunder Bay district showing the Kowkash gold



Sketch map showing the position of Kowkash relative to other mineral areas in northern Ontario.

area accompanied Part I, Volume 24, Report of the Ontario Bureau of Mines, 1915. The writer revisited the area in the latter part of October, 1915, and spent another six days in examining the geology and all the known discoveries. The Kawashkagama river below Johnson creek, part of O'Sullivan lake, and the greater part of the route along the railway between Johnson creek and Robinson lake, 25 miles west, were examined. Accompanying this report is a map of the area on a scale of four miles to the inch showing the topography, geology and location of the prospects.

[1] Kowkash Gold Area by P. E. Hopkins, Can. Min. Jour. Oct. 1, 1915, pp. 583-4.
[2] Map No. 24c, Ontario Bureau of Mines.

Location

The Kowkash gold area is situated in the central part of the district of Thunder Bay, Ontario, northeast of Lake Nipigon, and is traversed by the National Transcontinental railway. Kowkash station is 297 miles west of Cochrane at about latitude 50° 15′ north and longitude 87° 15′ west.

Early Exploration and History

A spectacular gold find was made by E. W. King Dodds on August 21, 1915, on claim T.B. 2424, nine miles northwest of Kowkash, near Howard falls, on the river Kawa-kash-kagama, which signifies "sparkling water". This name has been shortened to Kawashkagama by the Geographic Board. The railway station called "Kowkash"—an abbreviation or corruption of Kawashkagama—has given its name to this area. The region has so recently been opened up by the National Transcontinental railway that the geological reports have been for the most part of a preliminary character and confined to the more important canoe routes.

Kowkash station, National Transcontinental railway, September, 1915.

That part of the Kawashkagama river near the gold find is described by Robert Bell, in the annual report of the Geological Survey of Canada for 1870-1, p, 342; also, by party number 5 in the report on the Exploration of Northern Ontario, issued by the Ontario Department of Crown Lands, in the year 1900, p. 156. In the latter report, E. V. Neelands, geologist, blazed the way for the prospector when he stated:

> Huronian [Keewatin] rocks, mainly chlorite and other soft green schists, occur in the Kawa-kash-kagama river for about four miles below the Wawong portage to the northern limit of exploration [Howard falls]. . . . The most promising district is the country on the Kawa-kash-kagama river below the Wawong portage. Here Huronian [Keewatin] exposures are numerous, mostly chlorite and other soft green schists. Several samples from small quartz veins in this district showed traces of gold, and it might be that careful prospecting in this district would be rewarded.

W. J. Wilson of the Geological Survey of Canada also made a geological

reconnaissance survey [3] of part of this area in 1903-4, and his map [4] accompanying the report, which shows the water routes and geology, was very useful to the early prospectors. Robert Bell,[5] W. A. Parks,[6] A. H. A. Robinson [7] and others have described the canoe routes and geology on the western part of the accompanying map.

Up to the present time little attention has been given the Kowkash area by gold seekers, but part of the region was well known to some who prospected for iron on the Onaman iron range along Johnson creek. The iron first attracted the attention of the prospector in 1904, when engineers began the survey of the National Transcontinental railway through this area. R. Flaherty prospected on the range for two seasons, 1906-7, for the United States Steel Corporation, during which time much stripping and three diamond drill holes were sunk. However, the banded red jasper and magnetite and hematite proved to be of too low grade to be workable at that time. E. S. Moore [8] who spent part of two seasons in examining the range gives a detailed report on the geology and topography of this area.

From an economic point of view, gold is the chief interest in the region, at present.

Prospectors at the crossing of Johnson creek and National Transcontinental railway, September, 1915.

E. W. King Dodds made his discovery while walking over the rocky hill below Howard falls, which had been burned clean of moss and trees on the previous day. The news of the rich find caused a rush of about four hundred prospectors to the neighborhood, and 75 or 100 claims were staked within three weeks.

At the time of the writer's second visit at the end of October, no further discoveries had been made in the vicinity of the original find, around which centred

[3] Geological Reconnaissance of a portion of Algoma and Thunder Bay Districts, Geol. Surv. of Can., 1909, pp. 1-45.

[4] Map No. 964, scale 8 miles to inch. Geol. Surv. of Can., 2nd Edition, 1911.

[5] Geol. Surv. of Can., 1866-69, p. 344.

[6] Geol. Surv. of Can., 1901, Vol. XIV, pp. 105-109. A: Vol. XV, 1902, pp. 213-222.

[7] Report of party No. 6, on Survey and Exploration of Northern Ontario. Department of Crown Lands, 1900, pp. 162-172.

[8] Ont. Bur. Mines, Vol. XVII, 1908, pp. 170-189; Vol. XVIII, 1909, pp. 196-253.

the early staking. This was the magnet, however, that drew the prospectors to the locality, resulting in newer finds farther to the south and west. Two gold discoveries have been made farther up the Kawashkagama river, about three miles north of Kowkash station, on the Richardson and Dawson claims. Gold and a telluride have also been found on the Devanney claim near Tashota, 22 miles west of Kowkash, towards the western side of the Keewatin area. In the latter region as much staking has gone on as around the Dodds property. Gold values were obtained near Redmond station at mileage 54.3, from a quartz vein on O'Sullivan lake and other places. Mile posts are marked on telegraph poles along the line of railway west from Grant, a divisional point.

Over 1,000 claims have been staked mainly around Tashota, adjacent to the Dodds discovery, and in the vicinity of the railway between Kowkash and Tashota stations. Nearly 500 claims were recorded at the Port Arthur office up to November 11th, 1915. At the end of October there were about 100 prospectors still in the area.

Topography

The country has an average elevation of about 1,000 feet above sea level with no great variations in level. There is not a difference of more than about 150 feet between the highest hills and lowest valleys. The most prominent hill seen lies about four miles southwest of O'Sullivan lake.

The continental divide, separating the waters of the great lakes from those of Hudson bay, runs in a tortuous course through the region; but nowhere is it conspicuous as a ridge. A large swamp with streams emerging from either side often forms the watershed. A boss of red granite, three miles wide occurs at the divide, altitude 1,118 feet, at Redmond. Towards the northwest of the sheet is Summit lake, a shallow, muddy lake, three miles long by one mile wide, which discharges water both ways, the stream flowing northward towards the Albany being nearly as large as the southern outlet. The country northeast of the height of land is drained largely by the Kawashkagama river, a branch of the Albany.

The average magnetic declination for the area embraced by Map 25a is about one degree west of north.

Following is a brief resumé of the geology and a description of the several gold prospects.

General Geology

The Kowkash area presents pre-Cambrian rocks similar to those found elsewhere in northern Ontario. They are dominantly of Keewatin age, with some Timiskaming sediments and later intrusions of feldspar porphyry, granite and diabase. The younger formations can be separated when the area is mapped in detail. The above rocks cover an area of 600 or more square miles, which is worthy of further prospecting. Surrounding this region are rocks of Laurentian, Keweenawan and Paleozoic age.

Keewatin

The Keewatin consists chiefly of massive fine-grained chlorite and hornblende rocks which are in places altered to schists, and which have a nearly vertical dip. Among these rocks are altered diabase, altered basalt showing pillow or ellipsoidal structure, agglomerate and rusty carbonate, so much altered that microscopic examinations are unsatisfactory.

A considerable amount of Iron formation occurs on the Onaman iron range, the location of which is taken from E. S. Moore's map.

Cutting the greenstones and closely associated with the Iron formation are narrow dike-like masses and flows of quartz-porphyry or rhyolite. Exposures may be seen at many places, chiefly around O'Sullivan lake, Howard falls, Onaman iron range and Tashota station. The porphyry contains numerous white quartz phenocrysts, the size of peas, and some feldspar phenocrysts, in a fine-grained, greyish-white groundmass. The porphyry also contains some quartz stringers, is schistose in places and resembles the quartz porphyry at Porcupine,[9] Goodfish lake [10] and Big Duck lake [11] (north of Schreiber). A sample from the Dodds' claim which was examined microscopically showed large, rounded, angular and broken quartz grains, and albite phenocrysts, partly altered to sericite. The crystalline groundmass consists of quartz, feldspar, sericite, calcite and a little chlorite. E. S. Moore noted tourmaline in the rhyolite-porphyry from near Castor lake.

On the Kawashkagama river at the last portage into O'Sullivan lake is an actinolite rock, below which are numerous serpentine exposures.

Laurentian ?

Granite and gneiss, possibly of Laurentian age, are shown on the map, but these may include some granites of later age. Much of the gneiss is similar to the Laurentian gneiss in other parts of the pre-Cambrian shield. A. W. G. Wilson [12] notes that the acidic schistose rocks in the Summit-Marshall lake region occupy a very doubtful position between undoubtedly Keewatin and undoubtedly Laurentian.

Timiskamian

Conglomerates and slates apparently similar to the Timiskamian sediments in Porcupine and Kirkland lake are found about two miles below Howard falls and one chain from the west bank of the Kawashkagama river. They strike north 65° east and dip vertically. The pebbles of the conglomerate are rounded and drawn out, and consist of chert, quartz-porphyry, amygdaloidal basalt and granite-gneiss. The conglomerate is separated on the north by a few feet of drift from a large volume of pillow lava. Slates standing vertically can be seen at mileages 50.7, 51.7, 53.6 and elsewhere in the area. E. S. Moore has mapped a few exposures of tuff and conglomerate with the Keewatin.

Algoman ?

Cutting these older rocks are fresh-looking massive granite areas, probably of Algoman age. A grey granite can be seen at the water tank at Tashota station, which under the microscope shows quartz, albite, microcline and biotite. A large boss of red granite three miles wide forms the height of land, altitude 1,118 feet, at Redmond. It contains microcline showing the gridiron structure, albite with zonal structure, quartz and biotite partly altered to chlorite. Some of the quartz porphyries may be of Algoman age, apophyses from the larger granite masses. The feldspar porphyries are rare. A narrow dike was noticed cutting the iron formation at mileage 56.3 along the railway.

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[9] See Vol. 24, Pt. III, Ont. Bur. Mines, 1915.
[10] See Vol. 23, Pt. II, Ont. Bur. Mines, 1914.
[11] See Vol. 24, Pt. 1, Ont. Bur. Mines, 1915, pp. 9-13.
[12] Geology of Nipigon Basin, Ontario, Memoir No. 1, Geol. Surv. of Can., 1910, p. 50.

Keweenawan

Quartz diabase dikes occur in many parts of the area. Exposures may be seen at mileages 50.3, 50.5, and 56.7 west of Grant station. Large exposures of diabase and gabbro occur south of Tashota, and also about 300 yards north of the Dodds gold find. The only reason for placing these rocks in the Keweenawan is that they are similar in every respect to the Keweenawan diabase at Cobalt and in the Nipigon region. W. J. Wilson notes that the diabase is common in both the granites and schists and does not contain olivine.

Large areas of diabase occur around Lake Nipigon.[13] The occurrence of silver associated with the diabase at Silver islet and Silver mountain, 150 miles to the southwest, suggests the advisability of prospecting these diabase areas for silver.

Glacial and Recent

The region has been heavily glaciated, the ice movement having been from the northeast over the height of land in a general south-55°-west direction.

The area lies near the western edge of the northern Ontario clay belt, which has an extent of about 25 million acres, and is covered in places with stratified

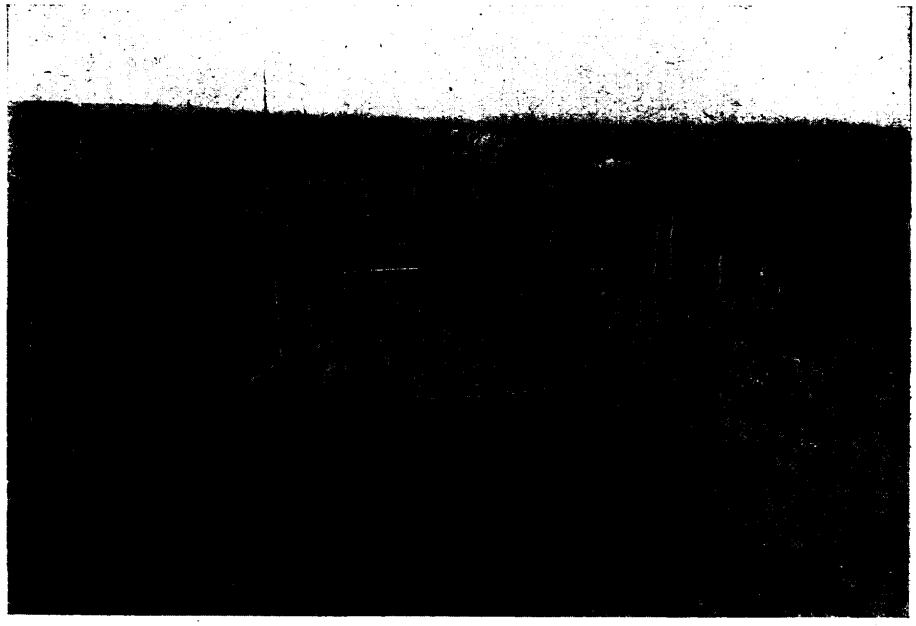


Photo by E. S. Moore.

Kettle lakes in terminal moraines near Johnson creek, south of Kowkash station.

clays, sands, gravels and coarse boulders. South of Kowkash station near the railway are numerous terminal morainic hills which contain many kettle lakes. Kowkash station is built on an outwash plain formed from an ice sheet.

Economic Geology

At present gold is the chief mineral sought for in the area, but there was considerable prospecting for iron in earlier years.

[13] See geological map No. 8A, scale 4 miles to the inch, accompanying Memoir No. 1, Geol. Surv. of Can., 1910.

Iron

The iron occurs on the Onaman iron range, which was examined in detail by E. S. Moore in 1907 and 1908. He found the iron formation to occur in two bands, called the northern and southern ranges, the former extending for nine miles and the latter three miles in an east and west direction. The formation is composed largely of red jasper, often well banded, and magnetite. There are considerable deposits of these minerals, but they are interbanded with much slate and some greywacké.

Gold

Quartz veins carrying gold values in parts of the area have been known for some time, particularly from the Cross-Summit lake area. A. H. A. Robinson, in 1900, obtained an assay return of 80 cents per ton from a vein on the west shore of Summit lake. Another sample on the Lily river, two miles from Summit lake yielded $2.80 of gold per ton.[14] W. A. Parks reports an assay value of $1 per ton in gold from a sample from Cross lake.[15] In 1900 E. V. Neelands obtained traces

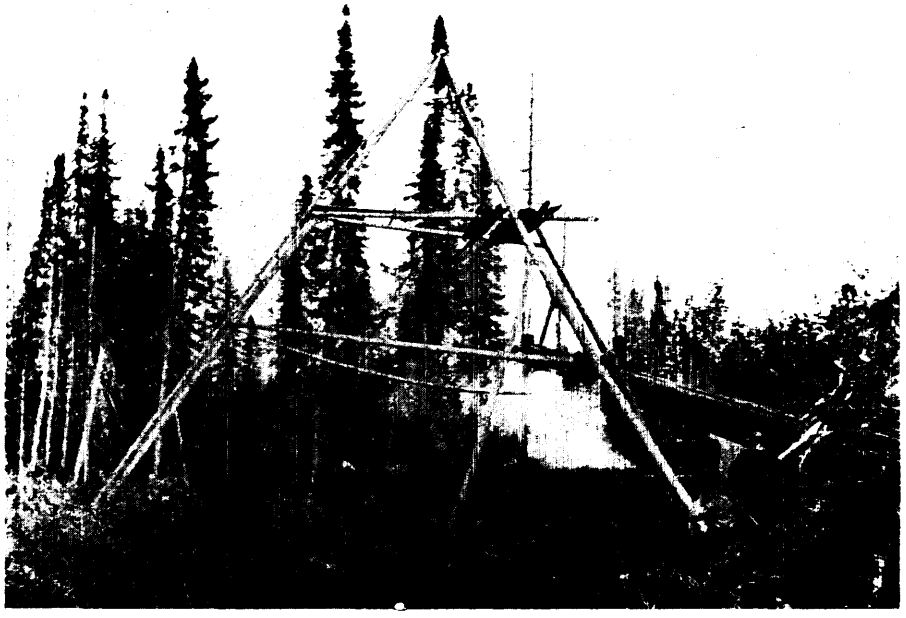


Photo by E. S. Moore

Flaherty's diamond drill prospecting for iron, Onaman iron range.

of gold from several samples collected along the Kawashkagama river above Howard falls.

Dodds' find in 1915 led to others, particulars of which are given below. The prospectors are still busily engaged in the region but enough prospecting has not yet been done to prove the prospects.

Other Minerals

A boulder of pyrite, about three feet across, was reported from a point about two miles northwest of Paska station.

[14] Survey and Exploration of Northern Ontario, Dept. of Crown Lands, Ont., 1900, p. 165.

[15] Geology and Natural Resources of the Northeastern Nipigon District, Geol. Surv. of Can., M.S. Report, 1902, p. 60.

A few specks of native copper were seen in quartz veins near the Tashota gravel pit.

No silver was present in the several samples which were assayed.

Other Resources

The trees are mostly second growth and consist of small spruce, poplar, balm of gilead, pine, birch and cedar, along the rivers occasionally attaining a diameter of two feet. On the whole, these are suitable for pulpwood and locally for ties, posts and small timber. Large areas have been recently burned. The east boundary of the Nipigon forest reserve, which is not surveyed, is approximately shown on the map.

Small tracts of the country are suitable for agricultural purposes.

Photo by W. J. Wilson.

Speckled trout 16" to 20" long; Albany river waters, Kowkash region.

Whitefish, pickerel, pike, suckers and brook trout are plentiful in these waters. The rapids on the Kawashkagama river and the numerous brooks entering the river are famed for their speckled trout, some of which are two feet in length.

Many small undeveloped water powers occur on the rivers. Howard falls on the Kawashkagama river would make an excellent water power. The 19-foot fall here is caused by a hornblende-chlorite ridge through which the river cuts, making a narrow canyon-like gorge fourteen chains long. W. J. Wilson notes that the gorge is from twenty to thirty feet deep, and the water descends in steps and slides varying from one to five feet.

Description of Gold Claims

The main properties visited are described as follows:

Dodds

The original gold find which caused the rush to the area was made on the Dodds' claim, T.B. 2424, about three-quarters of a mile east of Howard falls, on the Kawashkagama river. The quartz vein strikes 10° south of east and dips 75° to the north, thus conforming in strike and dip with the country rock. On the surface, the vein which is one to five inches wide, averages three inches in width. The quartz is somewhat glassy in appearance and largely free from sulphides. An abundance of free gold occurred for four or five feet along the hanging wall part of the vein. On the north side of the vein is a rusty schist band, six inches wide

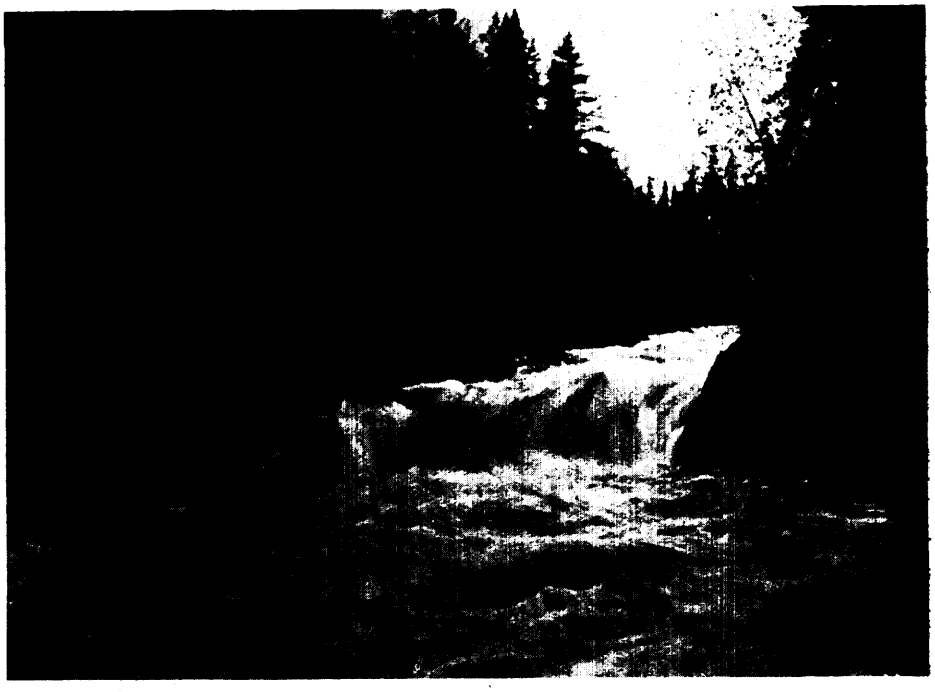


Photo by W. J. Wilson.

Howard falls, Kawashkagama (Kowkash) river.

which is heavily impregnated with iron pyrites. The wall rock is pillow lava (meta-basalt) altered in places to schist. Numerous quartz porphyry dikes up to thirty feet wide occur on the claim.

The claim was optioned by T. B. Caldwell, of Lanark, Ontario, and Messrs. Fraser and Orn. On October 23rd the vein had been stripped for 100 feet, exposing two specks of gold towards the western end, and a 14-foot pit had been sunk. In sinking, the showing of free gold disappeared in a few feet. At the bottom of the shaft the vein is two inches wide with a foot of pyritous schist on the foot wall, but no gold was visible. A channel sample across twelve inches of the pyritous schist from the bottom of the shaft gave an assay $2 in gold. Work was suspended early in November. It is reported that arrangements have been made to sink a 150-foot shaft.

Richardson—Loudon—Ogilvie

During the first week in October, 1915, gold was found on Claim T.B. 2599, near the first rapids on the Kawashkagama river below the junction of Johnson creek. The quartz vein is narrow, averaging about two inches in width over a length of 200 feet. The vein strikes south 85° east and dips about 70° to the south. The rock is Keewatin pillow lava, and near the vein is a biotite granite dike 6 feet wide. Coarse gold could be seen in 6 or 7 places along the vein, and pyrite is also present. Rock outcrops in this vicinity are scarce, but further trenching may reveal larger auriferous quartz veins.

Dawson

About two miles northwest of the Richardson claim across sand plains and intervening swamps is the Dawson claim, T.B. 2620, where gold was reported to have been found about October 22nd, 1915. The quartz vein strikes north and south for 400 feet and dips about 60° to the east. The vein is lenticular and will average about one foot in width. Chalcopyrite, pyrite and chalcocite are disseminated throughout the rusty quartz. The country rock is a massive, green, altered Keewatin diabase.

Devanney

On account of obtaining visible gold and high assays from the Devanney claim, near Tashota, 22 miles west of Kowkash station, as much staking has gone on around Tashota as around the Dodds' property.

The Devanney claim, T.B. 2650, lies about one and a quarter miles north of Tashota station on the northwest shore of Tashota lake. The vein strikes south 60° east and dips from 50° to 70° to the southwest. The vein is lenticular varying from a few inches up to four feet in width, and having an average width of a foot or more. It can be traced intermittently for about 600 feet. The quartz is milky, in places rusty, and contains a little fine gold, a telluride in considerable amount, also pyrite and pyrrhotite. A polished surface of the ore shows that there are probably three tellurides present. Three pieces of quartz containing a small amount of the tellurium mineral gave $27.60 in gold to the ton. The wall rock is a Keewatin greenstone consisting of chlorite, calcite and quartz. Quartz porphyry dikes occur on the claim and in the vicinity. The little trenching that has been done shows the prospect to be an interesting one.

McFarlane-Manion

At mileage 54.3 west of Grant, or four miles east of Redmond on the north side of the track on claim T.B. 2722, is a quartz-calcite vein, two to ten feet wide in a Keewatin greenstone which is said to extend across several claims in an east-west direction. Mr. McFarlane has sunk a pit 11 feet deep on the vein where it strikes south 70° east and dips 70° to the north. A one-half inch vein of galena occurs near the foot wall. Chipped samples for assay taken in three sections with a moil and hammer across the vein at the bottom of the pit gave as follows:

No. 1. 1½ ft. hanging wall part of vein, gold none; silver none.

No. 2. 3½ ft. centre of vein, gold $1.20; silver none.

No. 3. 1½ in. foot wall part of vein, containing galena, gold $6.00; silver none.

Conclusions

The Kowkash area, comprising 600 or more square miles, is similar geologically to other northern Ontario Keewatin areas, for instance, Porcupine. In

these schistose rocks quartz veins are plentiful. Gold, at this early stage, is known to be widely distributed. The Dodds vein contained a small rich pocket of ore, and the Devanney vein carries a telluride in addition to gold. Enough work has not been done to prove that the gold occurs in paying quantities. Prospecting is somewhat difficult in places on account of the heavy overburden, while other parts are rocky and burned. The transportation facilities are excellent on account of the railway and splendid waterways. The area is worthy of thorough prospecting, which it undoubtedly will receive during the coming summer. Besides gold, the prospector should be on the lookout for iron ore and pyrite.

In concluding, the writer wishes to express his thanks to W. R. Rogers, topographer, and P. A. Jackson, for the preparation and production of the map.

The assays were made by W. K. McNeill and T. E. Rothwell of the Provincial Assay Office.

End of Part I.

INDEX VOL. XXV., PART I

PAGE

A. 1 Silver claim, Gillies Limit.
Operations at, 1915 119
A. 98 Silver location, Gillies Limit.
Acquired by Trethewey Mining Co. .. 123
A. B. P. Mining Co. 128
Acetylene. *See* Calcium carbide.
Accidents. *See* Mining accidents.
Ackroyd, Robert 158
Actinolite.
Boston Creek, Blanche river 247
Acme gold mine.
Accidents 59, 64
Equipment 95
Ore reserves 96
Operation, costs 8, 93
Report on 95
Statistics 7
Ref. 44
Acme Gold Mines, Ltd.
See also Hollinger Consolidated Mines, Ltd.
Capitalization 94
Ref. 9, 90
Adair, Wm. 18
Adams, L. D. 156
Adanac silver mine.
Operations, 1915 104
Adanac Silver Mines, Ltd.
Directors and silver mine of 104
Ref. 42
Addington co.
Molybdenite 19, 134, 137
Agaunico silver mine.
Acquired by Coniagas Mines, Ltd. .. 109
Agawa iron formation.
Hunter island 165-167
Agawa lake, Hunter island 169
Iron ores 169, 177
Agglomerate.
Boston creek gold area 246, 247
Lake of the Woods region 166
Agnew, J. L. 69
Agricultural lands.
Pacaud tp. 253
Aikenhead, J. B. 102
Aikens & Beck 36
Airgiod silver claim. *See* Calumet and Montana silver mine.
Aitcheson, Thos. W. 161
Alabastine Co., Ltd.
Gypsum mines of 151
Officers of 151
Ref. 34
Aladdin silver mine.
Operations, 1915 104
Aladdin Cobalt Co., Ltd.
Directors and silver mines of 104
Ref. 11
Aldrich Gas & Oil Company, Ltd. 36
Aldworth, John 158

PAGE

Alexandra silver mine.
Operations, 1915 104
Alexo nickel mine.
Location 14
Operations, 1915 103
Production, 1915 15
Tax paid by, 1915 46
Alexo Mining Co., Ltd.
Directors and nickel mine of 103
Algoma dist.
Mining land sold and leased 45
Algoma Nickel Mining Company, Limited 42
Algoma Steel Corporation.
Furnaces and roasting plant 152
Mines of 69
Officers 152
Ref. 16, 17, 34, 193
Algoman.
Boston Creek gold area 250
Kirkland lake gold area 261, 262
Algunican Development Co. 135
See also Renfrew Molybdenum Mines.
Allen, C. W., Capt. 103
Allen, Solomon 23
Allen Bros. 158
Alsip, George 23
Altitude.
Boston creek 246
Goodfish lake 260
Aluminium dust.
Silver precipitant 118, 155
Alvinston Brick & Tile Co. 23
American Road Machine Co. 156
Amherstburg limestone quarry 144
Amos, A. A. 110
Analysis.
Argentite, Cobalt area 207, 208
Arsenopyrite, Cobalt area 228
Basalt, Boston Creek gold area 262
Breithauptite, Cobalt area 216
Calcium carbonate, Cobalt area 236
Chloanthite, Cobalt area 220
Cobaltite, Cobalt area 218, 223
Iron, Gunflint lake 187
Hunter island 169-171, 173, 175, 180, 181, 184, 185
Iron, Whitefish lake 187
Limestone, W. Flamborough tp. 145
Löllingite, Cobalt area 225, 226
Matildite, Cobalt area 232
Polybasite, Cobalt area 236
Proustite, Cobalt area 233
Rammelsbergite, Cobalt area 229
Silver (native), Cobalt area 203
Smaltite, Cobalt area 220
Symplesite, Cobalt area 237, 238
Zinc concentrate, Welland reduction works 155
Anchor, H. C. 89

PAGE
Anchorite Mining Company, Ltd.
Gold mines of 85
Anderson, Wm. 104
Anderson, W. G. 129
Anglin, C. S. 133
Anglin, F. R. 133
Anglin, J. E. 132, 133
Anglin, S. 133
Anglin mica mine.
Operations at, 1915 132
Anglin Mica Mining Co.
Mine of 132
Trimming works 133
Operations of 133
Anglin-Stoness-Gilbert Mica Co.
Scott mine operated by 133
Anglo-American Talc Corporation, Ltd.
Officers of 129
Operations of, 1915 129
Ref. 41
Angus, D. H.
Silver Queen mine leased by 122
Ref. 121
Annabel tp.
Limestone 146
Annable, Albert 158
Annabergite.
Cobalt area 239, 240
Animikie
Gunflint lake 166, 185, 187
Whitefish lake 187
Annis, George 27
Anstruther tp.
Molybdenite 20
Antimony.
Cobalt area 203, 204, 231, 238
Determination of 202
Apatite. *See also* Phosphate of lime.
N. Burgess tp. 133
Appleton, I. 80
Archean.
Hunter island iron deposits 166
Argentite.
In Cobalt area 204-208, 238, 239
analysis 207
deposition 243
photomicrograph 203
Armitage, Michael 161
Armstrong, Chas. 157
Armstrong, C. K. 157
Armstrong, F. C. 85
Armstrong, Geo. H. 23
Armstrong, John J. 158
Armstrong, R. A. 79
Armstrong, Thomas.
Molybdenite on farm of 20
Armstrong, Z. M. 157
Armstrong Bros. 23
Armstrong-McGibbon gold claims. *See* Anchorite Mining Co.
Armstrong Supply Co., Ltd.
Gravel-washing plant of 156
Officers of 157
Ref. 29, 158
Arnold, Thomas 158
Arnold, Willard 23
Arnott, James 158

PAGE
Arnott, Thos. H. 23
Arragonite.
Cobalt area 236
Arrow lake .
Iron 187
Arsenates.
Cobalt area 239
Arsenides.
Cobalt area, deposition 243
Separation of from sulphides 201
Arsenides of silver.
Cobalt area 205
Arsenic.
In Cobalt area, with silver, 13, 234, 239, 240
deposition 243
determination of 202
origin 205
Industry, 1915 31
Production 3, 4, 12
Refining 153-156
Statistics, 1911-15 32
Arsenopyrite.
In Cobalt area 225, 226, 227, 232
deposition 243
Arveson (?) 141
Assays.
Silver, Cobalt area 155
Statistics, Provincial Assay Office..48-49
Ashbridge Brick Co. 23
Ashdod, Bagot tp.
Molybdenite 19
Associated Gold Mines of Western Australia.
Keeley river mine worked by 126
Aube, Ephraim 158
Austin, L. E. 131
Authier-Charlebois gold claims....252, 258

Badger, H. S. 103
Baeckler, William 23
Bagot tp.
Molybdenite 17, 19, 136, 138
Bailey, A. C. 106, 114
Baird & Son, H. C. 23
Baker, Edwin B. 27
Baker, Geo. E. 23
Baker Bros. 23
Bald Mountains, Lanark co. 196
Ballantyne (?) 141
Baltimore and Cobourg Gravel Road Co. 158
Bannerman, R. C. 66
Bannerman and Horne 30
Granite quarry 66
Bannockburn pyrite mine.
Notes by Hopkins 192, 194, 195
Bapty, F. A. 155
Barbara silver mine.
Operations at, 1915 124
Barbeau, J. H. 149
Barite.
Porcupine area 102
Barnard, Argue Roth & Stearns Oil & Gas Co. 36
Barnes, William 29
Barrie tp.
Gold mining 129

PAGE
Bartlett, James 52, 66
Barton tp.
Limestone 146, 148
Bartonville gravel quarry 158
Bartonville Pressed Brick Co. 23
Basalt.
Goodfish lake area 262
Baskerville, Henry 161
Bass lake.
De-watering of 117
Ref. 11
Bassow, William M. 161
Basswood lake, Rainy River dist. 165
Bastard tp.
Limestone 141
Bathurst tp.
Mica mining 133
Battle, Joseph 30
Battle, J. A., Jr. 78
Baumhauer, H. 201, 219, 241
Bay of Quinte.
Limestone quarrying on 140, 143
Bazinet, Joseph 158
Beachville.
Limestone quarrying 150
Beachville White Lime Co.
Operations of, 1915 144
Ref. 27, 30
Bear's Passage, Rainy Lake.
Molybdenite 21
Beatty tp.
Gold mines 80
Molybdenite 20
Rhyolite 247
Beauchamp, F. X. 27
Beaument, Joseph 159
Beaver silver mine.
Deep exploration at 11
Operations, 1915 105
Production 10, 11
Tax paid by, 1915 46
Beaver Consolidated Mines, Ltd.
Directors of 104
Dividends 6
Kirkland Lake Gold Mines Co. optioned by 82
Silver mines of 105
Ref. 11
Beaver Oil & Gas Co., Limited 36
Beckett, E. C. 23
Becksted, Albert 158
Bedford tp.
Mica mining 133
Beeton, Wm. 111
Belgium Syndicate.
Molybdenite mine of 135
Bell, Annie 79
Bell, James H. 152
Bell, Dr. J. M. 99, 126
Bell, M. G. 146
Bell Bros. 23
Bell Bros. & Co. 23
Belle River oil field.
Production, 1915 40
Bellellen silver claim.
Operations at, 1915 125
Bellellen Syndicate 125
Belleville.
Limestone quarrying near 140
Bellew, H. C. 135
Belmont tp.
Molybdenite 20
Trap rock quarrying 142
Belmont Oil & Gas Company, Limited.. 42
Bemrose, Thos. 23
Bennett, A. G. 143
Bennet lake.
Mica mining near 133
Beno, Jos. W.
Gas and oil inspector 35
Report, 1915 35-36
Benzine.
Statistics, 1911-1915 40
Bergin, Patrick 27, 30
Berrick, Alfred A. 82
Berry, R. N. 36
Bertie tp.
Limestone 145, 149
Bertie Natural Gas Company, Limited. 36
Bickell, J. P. 97, 104
Big Duck lake (north of Schreiber).
Molybdenite 20
Big Master gold mine 66
Big Rock lake.
Iron deposits 178, 181
Water power 190
Bigsby, Dr. John 185
Billings pyrite mine, near Brockville.
Notes by Hopkins 192, 194-5
Bilsky, A. M. 122
Birch lake, Hunter island.
Birch 191
Forest fires 191, 196
Geology 167
Water power 190
Bismuth, Cobalt area.
Deposition 243
Method of analysis 202
Bismuth telluride.
Boston creek gold area 252
Bismuthinite.
Boston creek gold area 252
Bishop, F. J. 109
Bishop Silver Mines of Canada, Ltd.
Mining operations 124
Officers of 124
Black, W. A. 112
Blackburn, R.
Mica trimming 133
Black Donald graphite mine.
Operations at, 1915 138
Ref. 1
Black Donald Graphite Co., Ltd. 33
Black river, Lake Superior.
Molybdenite 20
Blain, Hugh 120
Blair, James 158
Blake, Elias D. 23
Blakely pyrite mine. *See* Queensboro mine.
Blanche river.
Agricultural land in valley of 253
Water power 253

PAGE

Blast furnaces.
Limestone flux for 144
analysis 145
Slag, for concrete 145
Southwest Ontario, report on 152
Welland 156
Blithfield tp., Renfrew Co.
Molybdenite 19
Pyrite 127
Blodgett, P. L. 110
Bobs lake.
Mica mining 133
Bogart Bros. 23
Bond & Bird 23
Bonnell, T. W. 159
Bonneville, J. A. 125
Bonis, David 150
Boone, Geo. H. 23
Booth, C. Jackson 119, 121
Boston creek.
Altitude 246
Rocks 246, 247, 254
Boston tp.
Gold in 251-263
Rocks 247, 249
Boston Creek gold area.
Report by Burrows and Hopkins 244
Ref. 8, 81
Bothwell oil field.
Production, 1915 40
Bott, Raywood 161
Bourne, A. J. 119
Bounty.
Petroleum 39
Bovaird, James 159
Bowker, S. T. 43
Bowman, C. M. 130
Bowmanville Gravel Company, Limited 42
Bowler, C. W. 23
Bowles, William 158
Boyle, Robin 149
Bradley, S. 143
Brampton Pressed Brick Co. 23
Brandon Pressed Brick & Tile Co. 23
Brant co.
Natural gas 39
Brantford Brick Co. 23
Brantford Gas Company, Limited 38
Brebner, D. A. 140
Breithauptite.
In Cobalt area 201, 209, 219, 241
analysis 216
etching for 210, 215, 216
micro-structure 212
photomicrograph 210, 211, 213
Brennan gold mine 260, 263
Brennan, M. J. 81
Brennan-Bower gold claim 263
Brick.
Industry 22
Manufacturers, list of 23
Production 22
Brief lake.
De-watering of 117
Ref. 11
Brigstocke, R. W. 78
Brisson, Charles 158

PAGE

Britnell & Co.
Limestone quarry 140
Ref. 30
Broadwell, Benj. 23
Brocklebank, Robert 114
Brockville.
Pyrite mining near 192, 194
Brockville Chemical Co. 194
See also Billings pyrite mine.
Bromley tp., Renfrew co.
Molybdenite 19
Brougham tp.
Graphite 138
Molybdenite 19, 135, 136
Broughton, W. A. 159
Brouse, James 158
Brouse, W. H. 119
Brown limestone quarry.
Operations at, 1915 144
Brown, Arthur H. 90, 111
Brown, E. A. 27
Brown, J. W. 23
Brown, Omar 141
Brown, O. C. 144
Brown, Thomas C. 123
Brown, W. B., & Sons 159
Brown & Bishop 187
Brown Bros. Brick Co. 23
Brownscombe, E. N. 23
Brownscombe & Sons, H. 23
Bruce copper mines.
Operations and equipment 73
Production, 1915 15
Quartz from for flux 30
Bruce co.
Limestone 146
Bryant, E. S. 101
Buchanan Bros. & Co. 23
Buck, James 159
Buck, J. L. 23
Bucke tp.
Silver mining 109, 110
Buffalo silver mine.
Native silver, analysis 203
Operations, 1915 105
Production 10, 11
Tax paid by, 1915 46
Buffalo & Dunnville Oil & Gas Co., Ltd. 36
Buffalo Mines, Ltd.
Directors and silver mine of 105
Dividends of 6
Flotation 12
Ref. 11
Teck-Hughes gold mines controlled by 83
Building stone.
Pacaud tp. 253
Production 3, 4
Statistics 29
Buklajezruk, George 64
Bunclark, John 113
Bunting, R. F. 139
Burgess.
Corundum mill at 140
Burgess tp.
Mica mining 133

PAGE
Burns, Dean 158
Burns farm, near Enterprise.
Molybdenite mine on 135
Burns molybdenite mine.
Operations at, 1915 135
Burrows, A. G.
Report by (and Hopkins) on Boston Creek gold area 244
Goodfish Lake gold area 260
Ref. 8, 81, 102
Burton tp.
Mica locations, 1915 44
Bushell, William 23
Bushnell, P. M. 104
Butwell Brick Co. 23
Butler, near Ignace.
Granite quarry 66
Buzz lake, Hunter island 169

C. 1141 silver location.
Title granted to Coniagas Mines, Ltd. 109
C. 1030. silver location.
Title granted to Coniagas Mines, Ltd. 109
Cabana, Oliver 23
Cable Excavator Co. 156
Cadwallader, Chas. S. 82
Cadwell Dredging Co., Limited 29
Cailloux molybdenite claim.
Operations at, 1915 135
Cailloux, L. L.
Molybdenite, mining of 135
Calabogie, Bagot tp.
Graphite mining near 33, 138
Molybdenite 19
Calcite.
Boston creek gold area 252
Boston tp. 249
Cobalt area 205, 224
cleavable variety 209
deposition 243
silver in 242
vein filling 213, 214
Goodfish lake gold area 261
Lanark co., with pyrite 196, 197
Calcite lake.
Silver mining at 124
Calcite, Mich.
Limestone imported from 152
Calcium arsenate.
Cobalt area 239
Calcium carbonate.
Cobalt area, analysis 236
Calcium carbide.
Industry, 1915 32
Production 4
Caldwell pyrite property.
Description and operation 199
Ref. 194
Caldwell, T. B.
Pyrite property of 127
Caledonia.
Gypsum mining near 151
Caledonia gypsum mine.
Operations at, 1915 151
Callaghan, S. J. 126
Callan, Charles 144
Callan & Bros., John 27

PAGE
Callow oil flotation process.
Buffalo silver mine 105
Massey copper mine 79
Calumet shaft, Adanac silver mine.... 104
Calumet and Montana silver mine.
Operations, 1915 105
Calumet and Montana Consolidated Mining Co., Ltd.
Directors of 106
Silver mines of 105
Calvin, J. J. 104
Cameron, Donald H. 67
Cameron, Lucy O. 67
Cameron, W. M. 27
Cameron Island gold mine 66
Cameron island, Shoal lake.
Gold mining 66
Cameron Island Syndicate, Ltd.
Mining operations of 66
Campbell, C. A. 43
Campbell, D. K. 159
Campbell, Neil F. 23
Campbell & Knight 201, 214
Canada pyrite mine.
Notes by Hopkins 194, 196
Canada Carbide Co.
Calcium carbide plant of 32
Canada Cement Co.
Limestone quarrying 140
List of plants 28
Port Colborne limestone quarry of.. 145
Canada Crushed Stone Corpn.
Limestone quarries of 144
Ref. 30
Canada Feldspar Corporation, Ltd. ... 33
Canada Iron Corporation 30
Limestone flux 148
Ref. 30
Canada Iron Mines, Ltd.
Officers of 128
Operations of 128
Canada Lime Co., Ltd.
Operations of, 1915 141
Ref. 27
Canadian Copper Co.
Accidents 64
Mines of 69
Production, 1915 15
Quartz quarry 72
Ref. 14
Signal system in shafts 60
Smelter, flux used at 30
Tax paid by, 1915 46
Winding ropes 59
Canadian Exploration Co., Ltd. 7-9
Canadian Feldspar Corporation, Ltd.
Mining operations, 1915 131
Canadian Furnace Co.
Blast furnace of 152
Safety appliance 153
Ref. 17
Canadian Gas Company, Limited 36
Canada Glass Mantle & Tile Co. 140
Canadian Gold and Silver Mining Co.
Alexandra mine leased by 104
Canadian Marble Co., Ltd. 30

PAGE
Canadian Mining Corporation, Ltd.
Holdings of, in Mining Corporation of Canada, Ltd. 114
Ref. 8
Canadian Mining and Finance Co., Ltd. 90
See also Hollinger Consolidated Mines, Ltd.
Canadian Niagara Power Co. 149
Canadian Nickel Co. 77
Canadian Pressed Brick Co. 23
Canadian Pyrites Co.
Operations of 196
Canadian Pyrites Syndicate 198
Canadian Quarries & Construction Co. 30
Canadian Quarries, Ltd.
Limestone quarry of 145
Ref. 30
Canadian Refining & Smelting Co. 153
See also Canadian Smelting & Refining Co.
Canadian Salt Company, Ltd. 41
Canadian Sand & Gravel Co., Limited.. 29
Canadian Smelting and Refining Co.
See also Orillia Molybdenum Co.
Cobalt refinery 153
Ref. 134
Canadian Sulphur Ore Co., Ltd.
Mining operations of 128, 197
Officers of 128
Pyrite mine 192
description 197
Ref. 34, 194
Canadian Talc and Silica Co.
See Eldorite, Ltd.
Canadian Towing & Wrecking Co., Ltd. 30
Candles. *See also* Paraffin.
Production, 1911-15 40
Canfield Natural Gas Company, Limited 36
Cann, John 161
Cannon, Martin 64
Carbonate.
Quartz veins cutting 85
Carborundum.
Competitor of corundum 32
Card, N. B. 23
Cardiff tp., Haliburton co.
Molybdenite mining 17, 20, 136, 138
Carlow tp.
Corundum 140
Molybdenite 20
Carmichael, H. G. 85
Carp lake.
Forest fires 163, 191
Iron ore 176, 177, 178
analysis 180
Rocks 167
Water power 190
Cart lake.
Hydraulicing near 118
Silver mining 114
Cartwright Gold Fields, Ltd.
Gold mines of, equipment 80
Carroll, Sylvester 125
Carson, John W. 109
Carson gypsum mine.
Operations at, 1915 151

PAGE
Carswell, Thomas 129
Cartmell, William R. 30
Casey tp.
Silver production 10
Casey Cobalt silver mine.
Argentite 206
analysis 207
Location 11
Operations, 1915 106
Tax paid by, 1915 46
Casey Cobalt Mining Co., Ltd.
Directors and silver mine of 106
Dividends of 6
Ref. 11
Casey Harris Mining Company, Limited 42
Casey Mountain silver mine.
Operations, 1915 106
Casey Mountain Syndicate 106
Casey Mountain Cobalt Mining and Development Co., Ltd.
Directors and silver mine of 106
Casey Seneca silver mine.
Operations, 1915 106
Casey Seneca Silver Mines, Ltd.
Directors and silver mine of 106
Ref. 42
Cashel tp., Hastings co.
Pyrite 194
Casselman, Emma 159
Casselman, Alfred 159
Catherine tp.
Gold in 246, 258
Rocks 247, 249
Cartwright, Burr E. 104
Cawrse, J. W. 102
Cedar lake, Timagami.
Pyrite mining near 103
Cement.
Limestone for 150
Cement brick.
Statistics 22
Cement, Portland.
List of plants 28
Production 3, 4
Central Ontario Granite & Marble Co., Ltd. 30
Central Pipe Line Co., Ltd. 38
Century silver mine.
See also Twentieth Century Mining Co.
Operations at, 1915 123
Chalcocite.
In Cobalt area 200, 208
analysis 209
Chalcopyrite.
Boston creek 252
Cobalt area 208, 209, 232
McElroy tp. 252
Queensboro mine 197
Chalmers, Margaret 27
Chalmers, Stewart 146
Chalmers limestone quarry.
Operations at, 1915 146
Chambers-Ferland silver mine.
Location 11
Royalties paid by 45
Champeau, O. 125

PAGE
Charest gold mine 252, 259
Charles, J. H. 156
Charlotte, New York State.
Feldspar grinding plant 131
Charron, Joseph 136
Chatham Gas Co., Ltd. 38
Chats island.
Lead mining 130
Cheddar.
Molybdenite near 138
Chesney, W. J. 159
Chestnut, William D. 27
Chinguacousy tp.
Limestone 149
Chippawa Development Co., Ltd. 36
Chippawa Oil & Gas Co., Ltd. 36
Chisholm, A. M. 17, 137
Chisholm, Dan 80
Chisholm molybdenite claim.
Mineralized zones on 137
Ref. 135
Christopherson (?) 125
Chlorite.
Boston Creek gold area 252
Chloanthite.
In Cobalt area 219, 221
photomicrograph 220
Christie, C. R. 141
Christie, D. D. 150
Church, M. B. 151
City of Cobalt silver mine.
Operations at, 1915 114
Royalties paid by 46
City of Cobalt Mining Co., Ltd.
Dividends of 6
Clarendon tp., Frontenac co.
Pyrite 194
Clark, Henry C. 83
Clarke, Richard 159
Clay.
Boston Creek gold area 246, 251, 253
Brick industry, statistics 22
Excavations inspected 158-162
St. Marys 150
Clay slate.
Lake of the Woods region 166
Cleary, Thomas 159
Clemens, Moses 23
Clements, J. Morgan 163, 165, 167, 180
Clergue tp.
Nickel mining 103
Clevenger, G. H. 204
Clevenger, T. B. 124
Clifford, Burton 159
Clifton Sand & Gravel Corporation.... 159
Coal.
Brick industry fuel 22, 23
Coast and Lakes Contracting Corporation.
Limestone quarry of 145
Ref. 30
Cobalt.
Bounties on 13
Cobalt area 214
Determination 202
Coinage purposes 12
PAGE
Electro-plating with 154
Industry 3
Production 12, 13
Refining 153-156
Cobalt carbonate.
Produced at Welland 156
Cobalt oxide.
Bounties on 13
Industry 13
Production 3, 4, 5
Refining 153-156
Cobalt sulphate.
Produced at Welland 156
Ref. 12
Cobalt lake.
Dewatering of, cost 11
Drainage of 115, 117
Cobalt lake fault.
Nipissing silver mine 118
Rich ore shoots discovered on 115
Cobalt silver area.
Accidents, number of 53
Arsenic produced from 31
Diabase 251
Flotation process 12
Industry, 1915 11
Milling practice 108
Mine dividends 6
Mining tax, revenue from 47
Nickel, metallic, from ores of 15
Refining of ore from 154
Report by Ellsworth on minerals of 200-243
Royalties from silver mines 45
Silver mining 104
production, 1904-1915 10
Cobalt Central Mines Co., Ltd.
Dividends of 6
Cobalt Comet silver mine.
See also Drummond mine.
Accidents 58, 64
Operations, 1915 108
Ref. 10
Tax paid by, 1915 46
Cobalt Comet Mines, Ltd. (Drummond).
Dividends of 6
Ref. 11
Cobalt Frontenac Mining Co.
Golden Fleece gold mine acquired by 128
Cobalt Lake silver mine.
Location 11
Operations at, 1915 114
Mill 117
flow-sheet 116
Cobalt Lake Mining Co., Ltd.
See also Mining Corporation of Canada.
Dividends of 6
Tax paid by, 1915 46
Cobalt Provincial silver mine.
Royalties paid by 45
Cobalt Reduction Co., Ltd.
Controlled by Mining Corporation of Canada 114
Mill, flow-sheet 107
operations, 1915 108

PAGE

Cobalt Silver Queen, Ltd.
Dividends of 6
Ref. 11, 122
Tax paid by, 1915 46
Cobalt Townsite silver mine.
Operations at, 1915 114
Royalties paid by 46
Cobalt Townsite Mining Co., Ltd.
Dividends of 6
Cobaltite.
In Cobalt area 209, 211, 221, 241
analysis 223
deposition 243
microscopic examination of...218, 219
micro-structure 212
photomicrograph 213, 222
Coboconk, Somerville tp.
Limestone near 141
quarrying 144
Cobourg municipality, Hamilton tp.
Gravel 160
Cody, F. S. 119
Coffey, Robert C. 102
Cohen, Samuel 81
Cohen, S. W. 109
Cohoe, John J. 123
Coke.
Fuel, brick industry 22, 23
Cole, Arthur A. 83
Cole, J. E. 19
Coleman, J. A. 36
Coleman, W. 128
Collacutt, Robert 159
Collins, Charles 73
Collins, E. A. 52, 66
Collins, John 161
Colorado, U.S.A.
Matildite 233
Colquhoun, George 159
Columbus silver mine.
Cobaltite from 221
Operations at, 1915 108
Columbus Cobalt Silver Co., Ltd.
Directors and mine of 108
Columbus, E. Whitby tp.
Gravel 160
Commonwealth Oil & Gas Co., Ltd. ... 36
Concentration.
Molybdenite 19, 20, 138
Conglomerate.
Boston Creek gold area 246, 249
Cobalt area 115, 118
Hunter island 165
Teck tp. 261
Coniagas silver mine.
Operations at, 1915 108-9
Production 10, 11
Refining of ore from 154
Tax paid by, 1915 46
Coniagas Mines, Ltd.
Directors of 109
Dividends of 6
Dobie claims optioned by 85
Silver mine 108
Ref. 11
Coniagas Reduction Co., Limited.
Arsenic refining 32
Bounties paid to, 1915 13

PAGE

Officers of 154
Refining of 12, 153
Coniston Smelter. *See also* Mond Nickel Co.
Accidents at 73
Alexo mine product shipped to..... 104
Flux used at 30
Ref. 73
Conlin, Fred. 159
Conn, Malcolm 161
Connell-McDonough gold mine 258
Connelly-Chown molybdenite mine 19
Connolly, Dr. 136
Connolly talc mine.
Operations at, 1915 129
Consolidated Brick & Tile Co. 23
Cook, J. S. 30, 146
Cook limestone quarry.
Operations at, 1915 146
Cooney, Lawrence 152
Cooper, James 109
Cooper, W. D. 122
Cooper, W. H. 23, 29
Copling, Peter 161
Copper.
Assays, Provincial Assay Office 48
Boston Creek gold area 252
Cobalt area 225, 227, 231
ores, determination of 202
with silver 240
Industry 14
Production 3, 4
to end 1915 5
Price 14
Copper arsenate.
Cobalt area 239
Copper pyrites. *See* Chalcopyrite.
Copper Cliff nickel mine.
Accidents 64
Copper Cliff smelter 89
Cordova gold mine 7
Cordova Mines, Ltd.
Closed in 1915 128
Ref. 9
Corkill, E. T. 69
Corless, C. V. 73
Corley, Richard 159
Cornhill Sons, Limited 23
Cornwall tp.
Limestone 142
Cornwall canal.
Limestone used in construction of.. 142
Corundum.
Mining of, 1915 140
Industry, 1915 32
Production 3
Costello, Wm. 81
Costello gold mine.
Discovery 260
Rocks 263
Costs (mining).
Cobalt silver area.
Crown Reserve mine 109, 110
La Rose mine 113
Kerr Lake mine 112
Nipissing mine 118
Trethewey mine 122

PAGE

Porcupine gold area.
Dome mine 85-86
Dome Lake mine 90
Hollinger mine 93
McIntyre mine 98
Porcupine Crown mine 100
Schumacher mine 102
Cottrell, M. F. 124
Couchiching formation.
Hunter island 155, 167
Coughlin, D. 31
Coulson, Duncan 119
Cowper tp.
Feldspar locations, 1915 44
Craig, E. 128
Craig pyrite mine. *See* Ontario Sulphur Mines, Ltd.
Craigmont corundum mine.
Accidents 58, 59, 64
Craigmont, Raglan tp.
Corundum mining 32
Molybdenite 20
Crawford, Bert 159
Crawford, John 159
Crawford Bros. 23
Crean Hill nickel mine.
Accidents 64
Location 14
Operations, 1915 69
Production, 1915 15
Credit Forks Brick & Tile Co. 23
Credit Valley sandstone 149
Creeper, John 159
Creighton nickel mine.
Accidents 58, 64
Location 14
Operations, 1915 69
Production, 1915 15
Ref. 1
Shaft-house, photo 71, 72
Shafts for large tonnage 70
Signal system, diagram 61
Crews, H. R. 124
Crews-McFarlane Mining Co., Ltd.
Mining operations 124
Officers of 124
Cristoff, Wasyl 64
Croesus gold mine, Munro tp. 7
Croesus Gold Mines, Ltd.
Gold mine of, operation and equipment 81
Ref. 9, 42
Croft, Robert 159
Cronin, D. E. 148
Crookston quarry.
Operation at, 1915 141
Crookston, Huntingdon tp.
Stone quarrying 141
Cross, F. G. 134
Cross and Wellington.
Fluorite mined by 130
Henderson talc mine leased by 130
Ref. 41
Cross lake.
Silver mining near 117
Crow, H. C. 80

PAGE

Crow Lake, Frontenac co.
Feldspar quarry near 33, 132
Crowe, B. C. 124
Crowhurst, W. J. 23
Crown Gypsum Co., Ltd.
Mine of 151
Ref. 34
Crown Reserve silver mine.
Operations at, 1915 109-110
Production 10, 11
Royalties paid by 45
Crown Reserve Mining Co., Ltd.
Dividends of 6
Capital and directors 109
McRae gold mine worked by 258
Mines of 110
Ref. 11
Crushed Stone, Ltd.
Operations of, 1915 141
Crystal City Oil & Gas Co., Ltd., The.. 36
Crystallography.
Argentite, Cobalt area 207
Culbert, M. T. 234
Culhane, John 19
Cullen, Andrew 82
Cullen-Renaud gold claims 258
Cullis, R. H. 102
Culver, Frank L. 82, 104, 122
Cumberland, J. M. 23
Cumberland municipality, Cumberland tp.
Gravel quarry of 160
Currie gold mine 255
Currie silver mine.
Operations at, 1915 125
Curtis, A. H. 85
Curtis, Edward 159
Curtis, Walter 159
Curtis Bros. 23
Cyanidation.
Cobalt area 108
Coniagas mine 109
Deloro reduction works 155
Teck-Hughes gold mine 83
Cyril Lake silver mine. *See* Calumet and Montana silver mine.

Dacre, Brougham tp.
Molybdenite 17, 19
Daimpre, C. G. 79
Dalby, Charles W. 102
Dalhousie tp., Lanark co.
Pyrite 194
Dane Mining Co. 252
Daniels, William 159
Daniels trap quarry 80
Danskin, D. 36
Darling tp., Lanark co.
Pyrite 194
Darlington Gravel Co., Ltd. 42
Darragh-Downey Mining Co., Ltd. 42
Davenport, B. F. 24
Davis, M. J. 159
Davis, M. B. 110
Davis (or Palmer) pyrite claim.
Description and operation 198
Ref. 194

PAGE
Day, Alexander 159
De Blois, W. H. 127
De Lamar, J. R. 85
De Lury, J. S. 221
De Pencier, H. P. 85
Deagle, John 36
Deller, Wm. H. 24
Deller & Sons, George 24
Deloro.
Refinery 154
Deloro tp.
Prospecting in 44
Deloro Mining and Reduction Co.
See also Deloro Smelting & Refining Co., Ltd.
Bounties paid to, 1915 13
Reorganized, 1916 154
Ref. 12
Deloro Smelting & Refining Co., Ltd.
Arsenic refining 32
Nickel, metallic, produced by 15
Officers of 155
Refinery 154
Delta, Bastard tp.
Limestone 141
Delta Lime Co., Ltd.
Operations of, 1915 141
Ref. 27
Denison, Chas. L. 83
Department of Mines, Ottawa.
Molybdenite concentration tests by.. 134
Deschamps, Oliver 125
Desert Lake feldspar mine 33, 132
Diabase.
Cobalt area 122, 251
Kerr lake 111
Goodfish Lake gold area 260
Gunflint lake 187
Lebel tp., Doig lake 247
Dickenson, J. G. 119, 124
Dickson, Chas. C. 102
Digby tp.
Molybdenite 20
Dill tp.
Quartz quarry 72
Dividends.
Beaver silver mine, 1915 105
Mining companies 5, 6
Nipissing silver mine 117
Peterson Lake silver mine 120
Tough-Oakes gold mine 83
Dobell, W. M. 112
Dobie, S. J. 85
Dobie gold mine. *See* Anchorite Mining Co.
Dobie-Leyson gold mine. *See* Croesus Gold Mines, Ltd.
Dobie Mines, Ltd. *See also* Tisdale Gold Mining Co.
Gold claims of 85
Dodds, E. King 8
Doig lake, Lebel tp.
Greenstone, spherulitic structure.... 247
Dolly Varden.
Limestone quarrying 150
Dome gold mine.
Accidents 64
PAGE
Equipment of 86-88
Operations, 1915 ..... 85, 86
costs 8
Shaft of, for big tonnage 86
Shaft framing, diagram 87
Statistics, 1915 7
Tax paid by, 1915 46
Ref. 5
Dome Consolidated Mines, Limited ... 42
Dome Extension gold claim.
Option on secured by Dome Mines.. 89
Dome Extension Mines Co., Ltd.
Officers of 89
Dome Lake gold mine.
Development of 89
Ref. 7, 44
Dome Lake Mining & Milling Co., Ltd.
Capitalization 89
Officers 90
Ref. 9
Dome Mines Company, Ltd.
Capital and directors 85
Dividends of 6
Ref. 9
Dominion Brick & Tile Co. 24
Dominion Feldspar Co., Parham 33
Dominion Lime Co., Ltd. 42
Dominion Mines & Quarries Co., Ltd.
Quartzite quarry of..... 80
Dominion Natural Gas Co., Ltd. 37
Operations and production, 1915 ... 36
Dominion Reduction Co.
Brennan-Bowes group optioned to... 265
Customs mill of 110
Refinery 12
Dominion Salt Co., Ltd. 41
Dominion Sewer Pipe Co. 24, 27
Donaldson, Wm. J. 119
Donaldson Bros. 24
Don Valley Brick Works 24
Doolittle, Charles M. 145
Dorfman, A. 98
Douglas, W. A. 37
Dowding, Albert 161
Downing, Charles 144
Doyle, Michael 159
Doyle, William 159
Drain tile.
Industry and statistics 22
Drummond silver mine.
Ref. 10, 11
Tax paid by, 1915 46
Drummond Fraction silver claim.
Location 11
Worked by Crown Reserve Mining Co. 110
Drury, Prof. C. W.
"Drury slag" 33
Potash fertilizer 33
Dryden.
Molybdenite near 21
Dryden Timber and Power Co. 67
Dublin Brick & Tile Works 24
Duckett, J. H. 27
Dunbar, Williamsburg tp.
Limestone quarrying near 142

PAGE

Dundas.
Limestone quarrying 144
Dundonald tp.
Nickel mining 103
Dungannon tp.
Marble 140
Molybdenite 20
Dunlap, David A. 94
Dunmead, Wm. 104
Dunn Natural Gas Co., Ltd. 37
Durivage, A. F. 159
Durr, Lewis H. 161
Dutton oil field.
Production, 1915 40
Duxbury, Wellington 37
Dwyer, Timothy 18
Dyscrasite, Cobalt area 238
Photomicrograph 203

E. 58, iron claim, Hunter island 180
Eames, L. B. 94
Earle, E. P. 119
Earlton Salt Works Co., Ltd. 41
East Neebish island, St. Mary's river.
Quartzite 80
East Neebish quartzite quarry.
Operations and equipment 80
Eastern Ontario mining division.
Administration of 43
Eastside Gas Co., Ltd. 37
Eckstein, John 161
Edwards, W. S. 85, 89
Eganville.
Molybdenite mining near 134
Eganville limestone quarry.
Operations at, 1915 141
Eganville, Grattan tp.
Limestone quarry near 141
Eggleston, H. J. 146
Eldon tp., Victoria co.
Stone crushing industry 141
Eldorite, Ltd.
Ref. 41
Talc mine of 129
Eldredge, Winfield S. 58
Electro-plating.
Cobalt for 154
Electro-Metallurgical Co., Niagara Falls, N.Y.
Ferro-silicon manufactured by 80
Electro Zinc Co., Ltd.
Officers of 156
Refinery 155
Elgin gas field.
Production, 1915 39
Elizabethtown tp.
Pyrites 194
Elk-Horn Lime Co., Ltd. 42
Elk Lake silver area.
Mining operations, 1915 123
Elliott, William 24
Elliott & Bolmer 138
Ellsworth, H. V.
Report by, on minerals Cobalt area 200-243

PAGE

Elmore Oil process. *See also* Flotation.
Massey copper mine 79
Molybdenite, Renfrew co. 19
Elora White Lime Co., Ltd. 42
Elstone-Dunkin Mines, Ltd. 244
Ely formation.
Hunter island 165, 166, 167
Emard, Treffle 24
Emerald lake.
Forest fires 191
Iron deposits 176, 178-180
analysis 180
Route to Hunter island iron area ... 163
Emerald lake, Timagami forest reserve.
Gold mining near 103
Emerson, Troughton & Laidlaw 37
Empey, Guy 159
Empire Limestone Co., Ltd.
Quarries and gas wells of 146
Ref. 29, 31, 37
Empire Sand & Gravel Co., Ltd. 42
Ennis, R. J. 98
Enniskillen tp.
Boring for oil, depth 35
Enterprise.
Molybdenite mining near 135
Enterprise Gas Co., Ltd. 37
Enterprise Sta., Lennox & Addington co.
Pyrite 194
Erb, Christian 161
Erb, Dilman K. 161
Erb, John G. 161
Erythrite.
Cobalt area 239
analysis 240
Escott.
Granite quarry near 142
Esquesing tp.
Limestone 148, 150
Sandstone 146, 147
Essery, W. H. 141
Essex County Light & Power Co. 158
Essex gas field.
Gas line inspection 35
Producing wells, 1915 ..... 35, 36
Euxenite.
Description of 49
Evans, Alex.
Molybdenite discovered on farm of 20, 138
Evanturel tp.
Limestone 247
Evered, N. J. 99
Explosives.
Accidents from 55, 56-58
Hints on using 58
Hoisting 60
Explosives magazine.
Creighton nickel mine 70
Exeter Salt Works Co., Ltd. 41

Faced Brick and Machinery Co., Ltd. 42
Fairbank Estate, J. H. 37
Fairlie, M. F. 108
Faraday tp.
Marble 140
Farah, K. 253

PAGE
Farr, L. G. 31
Farrell pyrite mine.
Description and operation 198
Ref. 194
Fasken, Alex. 85, 89, 104
Fasken, David 119
Fatalities. *See* Mining Accidents.
Feeny, John L. 119
Feldspar.
Cowper tp. 44
Industry, 1915 32
Mining of 131
Production 3, 4
Verona 1
Felsite.
Boston Creek gold area 249
Ferguson, C. 126
Ferland, Arthur 104
Ferro-molybdenum.
Orillia 134
Ferro-silicon.
Niagara Falls, N.Y. 80
Fewster, Robt. 161
Fillion, S. O.
Mica trimming works 133
Ref. 135
Filtration.
Hollinger gold mine 93
Teck-Hughes gold mine 83
Finkenstaedt, F. C. 105
Finnegan, Chas. 161
Finucane, T. R. 114
Finucane, Thos. W. 114
Fireproof blocks 151
Fischle, G. C. 151
Fish.
Hunter island region lakes 191
Fisherville Gas Co. 37
Fitzroy tp.
Lead mining 130
Flamborough tp. W.
Limestone 144
analysis 145
Flanagan, D. D. 114
Flanagan, O. L. 117
Flatstone lake. *See* Irene lake.
Fleming, J. H. 31, 146
Fleming, Robt. 161
Fleming sandstone quarry.
Operations at, 1915 146
Fletcher, D. E. 129
Fletcher, D. H. 128
Flieler, E. & F. 27
Floete, Franklin 68
Flotation process.
Buffalo mine 105
Cobalt area 11, 12
Massey copper mine 79
Molybdenite, Renfrew co. 19
Nipissing silver mine 118
Fluorite.
Mining, 1915 130
Fluorspar.
Production 4
Flynn, C. B. 98, 110
Flynn, James F.
Massey mine reopened by 79
PAGE
Flynn, Thomas J. 110
Foley, J. W. 144
Foley pyrite mine.
Description and operation 199
Ref. 194
Foley tp.
Molybdenite 20
Foote, William B. 58
Forest fires.
Boston Creek gold area 253
Hunter island 191
Forgues, Dieudonne 159
Forman, Stephen 24
Fort Frances mining division.
Administration of 43
Fort William Brick & Tile Co. 24
Foster, C. A. 83
Foster, F. W. 159
Foster, Robert 143
Foster silver mine.
Chalcocite, analysis 209
Leased by Glen Lake Mines, Ltd.... 110
Smaltite 219
Tax paid by, 1915 46
Foster Cobalt Mining Co., Ltd.
Dividends of 6
Foster silver mine leased by 110
Fox, G. J. 23
Fraleck, E. L.
Ref. 195, 198
Views of, on gossan capping pyrite.. 198
Francis, J. G. 161
Frank, E. D. 24
Franz, W. C. 152
Fraser, A. W. 121
Fraser, Charles 24
Fraser, Wilmot 161
Freek, William 24
Fretz, Jacob M. 31
Frey, David S. 27
Friars, Austin 99
Frid Brick Co., George 24
Frid Bros. 24
Froats, Chas. A. 121
Frontenac co.
Feldspar mining 33
Molybdenite 134
Pyrite 194
Frontenac Floor & Wall Tile Co., Kingston 33
Frost, George H. 24
Fuel.
Brick industry, costs 22
Lime industry 27
Fuller, F. F. 104
Fuller, George 24
Fuller, M. B. 146
Fyfe, Joseph B. 113

Galena. *See also* Lead.
Cobalt area 208, 232
Galetta lead mine.
Operations at, 1915 130
Gallagher, Dan. 146
Gallagher Lime & Stone Co.
Limestone quarry of 146
Ref. 31

PAGE
Game.
Hunter island iron region 191
Gamey, R. R. 19, 137
Gami lake, Teck tp.
Conglomerate 261
Gananoque.
Granite quarry near 142, 144
Gardiner, William 24
Garlough, Jacob 159
Garnets.
Pacaud tp. 250
Lanark co., pyrite deposits 196
Garrow tp.
Molybdenite discovered 44
Garson nickel mine.
Accidents 58, 64
Location 14
Operations at 74
Production, 1915 15
Garvey, Timothy 159
Gas, natural.
Distributors, list of 38
Empire Limestone Co. 146
Fuel, brick industry 22, 23
Production, 1915 .....3, 4, 35, 39
Report by Mickle 39
Taxation, revenue 47
Wells, number 35
Producers, list of 36
Gasolene.
Demand for 39
Gauthier, G. H. 43
Gauthier, Nap. 159
Gauthier tp.
Silver mining 123
Gear, W. J. 109
General Chemical Co.
Bonus paid to employees 78
General Chemical Co., New York.
Northern Pyrites mine controlled by 67-68
General Electric Co.
Mica trimming works 133
Genesee silver mine.
Operations of, 1915 110
Genesee Mining Co., Ltd.
Directors and mine of 110
Ref. 42
Geology.
Boston Creek gold area 246
Goodfish Lake gold area 260
Hunter Island iron area 166
George & Sons, Mrs. E. D. 24
George Frid Brick Co., Ltd. 42
Gersdorffite.
Cobalt area 222
Gibson, James 159
Gibson, T. W. 163
Gibson gold claim 260
Gilchrist, R. J. 129
Gillard, David 159
Gillespie, Geo. H. 128
Gillespie, George H., & Co.
Talc mill of 130
Ref. 41
Gillespie, John 159
PAGE
Gillies Limit.
Silver mining 109, 119, 123
Giroux, Fred. 126
Giroux silver claim.
Operations at, 1915 126
Glaciation.
Boston Creek gold area 251
Glaucodot.
Cobalt area 230
Glen lake.
Silver mining 110
Glen Lake Mines, Ltd.
Directors and mine of 110
Glenwood.
Gas pumping plant 36
Glenwood Natural Gas Co., Ltd. 37
Globe, A. R. 94
Globe graphite mine.
Operations at, 1915 139
Globe Consolidated Lease Incorporated Co.
Control of acquired by Crown Reserve Mining Co. 110
Globe Graphite Mining & Refining Co., Ltd.
Officers of 139
Operations of 139
Ref. 42
Globe Refining Co. 139
Gloven, M. E. 146
Gloucester tp.
Limestone 142, 143
Godard, Michael 159
Goethite.
With calcite 215
Gold, Chas. Major 104
Gold.
Assays, Provincial Assay Office 48
Boston Creek gold area 253
Eastern Ontario mines 128
Goldfish Lake gold area 260-263
Industry 7
Lanark co., Hungerford mine 196
Production 3, 4, 8
total to end 1915 5
Taxes paid by mines 46
Timiskaming dist., Inspector's report 80
Gold Anchor Mining Company, Ltd. .. 42
Golden Fleece gold mine.
Operations of, 1915 128
Gold Reef gold mine 7
Gold Reef Gold Mine, Ltd. 9
Golden Rose gold mine.
Operations at, 1915 103
Golden Rose Mining Co., Ltd.
Gold mine and officers of 103
Goldschmidt, V. 207, 215
Goodale, Emerson 29
Gooderham, Geo. H. 150
Goodfish lake.
Altitude 260
Gold mines near 82
Goodfish Gold Mines, Ltd.
Mine development 81
Goodfish Lake gold area—Bernhardt, Morrissette, Teck and Lebel tps.
Report by Burrows and Hopkins.260-263

PAGE
Goodfish Lake Mines, Ltd. 263
Gordon & Bruce 30
Gordon & Son 142
Gorsline, Ralph H. 110
Gosselin Charles 31, 142
Gosselin limestone quarry.
Operations at, 1915 142
Gottschalk & Buchler 201
Gould, E. L. 123
Gould, Francis E. 29
Gould Allied Mines, Limited 42
Goudreau lake.
Pyrite deposits 193
Goudreau pyrite mine.
Operation and equipment 77
Ref. 34
Govenlock, J. M. 24
Gowanlock, J. 24
Gowdy, Wm. 150
Gowganda mining division.
Office statistics, 1915 43
Gowganda silver area.
Mining report, 1915 124
Production 10
Gowganda Enterprise Mining Company, Ltd. 42
Gowland, Isaac 159
Goyette, A. E. 135
Graham James, ... 159
Graham, R. 122
Graham tp.
Molybdenite 20
Grand river, Haldimand co.
Gypsum mining 33, 151
Grand Portage, Minnesota.
Lakes of, description 165
Granite.
Boston Creek gold area 250, 253
Butler, paving blocks 66
Eastern Ontario 142, 144
Hunter island 165, 166
Production statistics 29
Quarries, list of 30
Granite Crushed & Dimension, Ltd. .. 30
Grant, G. P. 134
Graphite.
Calabogie 1
Embargo on 33
Gillies Limit, in silver veins 119
Industry, 1915 33
Mining of, 1915 138
Production 3, 4
Grasselli Chemical Co.
Purchasers of pyrite 34
Sulphuric acid plant 192
Grassy river, tributary of Mattagami. 7
Grattan tp.
Limestone 141
Gravel.
Boston Creek gold area 251
Industry 3, 4
Leasing regulations 28
Producers, list of 29, 158-162
Statistics 28-29
Washing plants 156
Gravenhurst Crushed Granite Co., Ltd.
Quarry of 146

PAGE
Graves, Geo. 161
Gray, George 137
Gray, George R. 19
Greenawalt roasting process.
Helen iron mine 69
Greene, R. T. 119
Greenstone.
Boston Creek gold area 247
Goodfish lake gold area 260
Hunter island 165
Lake of the Woods region 166
Greer, A. B. 102
Grenville limestone.
Storrington tp. 29
Grew, Frank 67
Greywacké.
Boston Creek gold area 249
Grierson, A. W. 104
Grierson and Gallagher.
Mica mining operations of 133
Ref. 132
Grieves, John, M.P.P. 161
Griffin, J. A. 159
Griffith, Johnson 159
Griffith tp., Renfrew co.
Molybdenite 19, 138
Grills, J. J. 111
Guelph.
Limestone quarrying 149
Gull lake.
Molybdenite 21
Gunflint lake iron area.
Map 186
Report on, by Parsons 185-191
Trees 191
Water power 188
photo 189
Gunter pyrite claim.
Description and operation 199
Ref. 194
Gypsum.
Industry, 1915 34
Production 3, 4
Report on mines 151

H. R. 937-8-9 gold loc. 90
Habgood, W. H. 123
Haentschel, Dr. C. W. 119
Hager, Ham 37
Hagerman, Anson V. 29
Hagersville.
Limestone quarrying 147, 148
Hagersville Contracting Co.
Quarry of 31, 147
Hagersville Crushed Stone Co.
Quarry of 147
Ref. 31
Haig, J. A. 129
Haileybury.
Agricultural land, north of 253
Haileybury Kirkland Lake Mining Co., Ltd. 42
Haines, Jansen D. 120
Haines, Robt. B. 120
Haines, Wm. J. 120
Haire, R. E. 151

PAGE
Haldimand co.
Gypsum mining 34
Natural gas 39
Haley, Horton tp.
Marble quarrying near 140
Molybdenite near 137
Haliburton co.
Molybdenite mines 20, 134
Hall Estate, Ellen 24
Hall, Oliver 73
Hall, Stuart W. 131
Hallatt, H. 24
Hallman, J. B. 24
Halton co.
Sandstone 146
Hambleton, Robert 147
Hambly, W. J. 73
Hamilton, Alex. M. 37
Hamilton, F. H. 99
Hamilton, Robert 159
Hamilton, W. A. 123
Hamilton.
Blast furnaces 153
Limestone quarrying near 148
Natural gas supplied to 36
Sand and gravel quarries 31
Washing plants 156, 157
Sulphuric acid plant 192
Hamilton steel works.
Limestone flux for 144
analysis 145
Hamilton and Toronto Sewer Pipe Co. 27
Hamilton Pressed Brick Co. 24
Hamilton Sand and Gravel, Ltd.
Gravel washing plant of 157
Officers of 157
Ref. 159
Hamley, R. H. 24
Hancock, William 24
Haney, M. J. 143
Hanna, H. 79
Hanning, G. H. 103
Hanover Portland Cement Co. 28
Hansen, Edward 112
Hansen, George H. O. 80
Hansen, Hans Christian 29
Harbour Brick Co. 24
Harcourt.
Graphite mill at 139
Harcourt, Prof.
Ref. to report of, on potash fertilizer 33
Harcourt tp., Haliburton co.
Molybdenite mining 20
Hargrave silver mine.
Royalties paid by 45
Harkness, J. G. 126
Harlock, Joseph 159
Harper, George H. 147
Harris, James 161
Harris Development & Exploration Syndicate, Limited 42
Harrison limestone quarry.
Operations at, 1915 ..... 147, 148
Harrison, H. B. 147
Harrison & Beatty 31
Hart & Harrington 37
PAGE
Harvey, E. 147
Harvey, E., Ltd.
Limestone quarry of 147
Ref. 27
Harwood, T. J. 113
Hasselbring, A. 69
Hastie, Maurice 102
Hastings co.
Corundum 140
Graphite mining 33
Ornamental marble 29
Pyrite mines 192, 194
Hastings County Marble Company, Ltd. 42
Hastings Quarries, Ltd. 30, 31
Haston, John 146
Havelock, Belmont tp.
Trap rock quarrying near 142
Hawley, H. A. 131
Hay, Alex. M. 98, 120, 123
Hayden, Wm. H. 90
Hayden Gold Mines, Ltd.
Officers and gold mines of 90
Healey, Frank 159
Helen iron mine.
Location 16
Operations at 69
Ores smelted from 152
Pyrite 34
production 193
Helldiver bay, Shoal lake, Kenora.
Gold mining 68
Hematite.
Boston Creek gold area 252, 259
Gossan capping to sulphide ore bodies 198
Helen iron mine 69
Hunter island 167, 170-172, 176
Hendee Natural Gas Co., Ltd. 37
Henderson, James 142
Henderson talc mine 130
Henley, E. S. 103
Hepworth Silica Pressed Brick Co., Ltd. 24
Herbert, Dennis 104
Hewitson copper claim 67
Hewitt lake.
Silver mining near 124
Hewitt Lake Mining Syndicate.
Mining operations of 124
Officers of 124
Higgins, D. J. 153
Higginson & Stevens 27
Higgs, W. H. 90
High falls, Blanche river.
Water power 253
Hill, James M. 48
Hill, Roland 161
Hill, Sanford 24
Hill & Sons, James S. 24
Hill Bros. 24
Hinde Bros. 24
Hintze (?) 228
Hintze & Dana 219, 233
Hiscock & Sons 24
Hitch, John 24
Hitch, Susan 24
Hitch, Thomas 24
Hobson, Robert 153

PAGE
Hodgins, Geo. 162
Hohl, George 24
Hoist.
Creighton nickel mine 71
Safety clutch, description 88
Safety device for 76
Hoisting.
Signals for 60
Holden, John B. 102
Hollinger gold mine.
Operating costs 8
Operations, 1915 91
Ore reserves at 94
Shaft framing, diagram 92
Statistics, 1915 7
Tax paid by, 1915 46
Ref. 5
Hollinger Consolidated Mines, Ltd.
Capitalization 90
Officers of 91
Hollinger Gold Mines, Ltd.
See also Hollinger Consolidated Mines, Ltd.
Dividends of 6
Mining operations, 1915 91
Ref. 9, 90
Holmes, A. S. 119
Holmes, Harvey L. 103
Holmes, J. A. 77
Holmes Gas Company, Limited 37
Holmstead, A. W. 128
Holton, Fred. E. 24
Holton, R. J. 24
Honey, Stephen 159
Hooper, Edward 99
Hooper, Wm. 106
Hooper pneumatic concentrator.
Molybdenite treatment 19
Hoover, D. E. 37
Hoover, D. E., A. E., and M. 37
Hoover, James E. 37
Hopkins, A. Y. 19
Hopkins, P. E.
Report by, on Kowkash gold area... 264
Report by (and Burrows) on Boston Creek gold area 244
Goodfish lake area 260
Report by, on iron pyrites, southeastern Ontario 192-199
Ref. 8
Hornblende granite.
Lanark co., pyrite deposits 196
Hornblende schist.
Gunflint lake 188
Horne, Wm. 66
Horscroft, T. 18
Horton tp.
Limestone 143
Marble 140
Hotchkin and Grover 253
Hough, J. A. 43
Houston, Joseph C. 102
Howey, George 31
Howland nickel mine.
Operations at 77
Howlett, C. C. 148
Howlett, Fred. 24
Hubner, Emil 68
Hudson Bay silver mine. PAGE
Breithauptite 209
Operations at, 1915 111
Royalties paid by 45
Hudson Bay Mines, Ltd.
Directors and silver mine of 111
Ref. 209
Humberstone tp.
Limestone 145, 146
Humbug point, St. Joseph's Island.
Trap quarry 80
Hume, R. Wesley 159
Hungerford pyrite mine.
Description and operation 194, 196
Hungerford Talc Co., Ltd. 42
Hungerford tp., Hastings co.
Pyrite 194
Hungerford Western Extension pyrite mine 194
Description and operation 197
Hunn, Joseph S. 114
Hunt, Alfred E. 161
Hunter, Samuel 19
Hunter island, Rainy River district.
Iron deposits, Report by Parsons. 163-185
Map 164
mining claims 168
Water power 188
Huntington tp.
Fluorite mining 130
Stone quarrying 141
Hurlburt, George 131
Hurlburt feldspar mine.
Operations at, 1915 131
Huronian.
Hunter island 166
Hurst, Samuel H. 147
Hurst sandstone quarry.
Operations at, 1915 147
Hussey, J. P. 69
Hutchinson, F. L. 90, 111
Hyde, F. W. 37
Hyde & Snively 37
Hydraulicing.
Costs at Nipissing silver mine 118
Hydrochloric acid.
Sulphide, Ont. 196
Hydromica.
Lake of the Woods region 166
Hyland, George 159

Illuminating oil. *See* Oil.
Imperial Reserve Mines, Limited 42
Independent Natural Gas Co. 38
Industrial Natural Gas Co., Ltd. 37
Ingersoll.
Limestone quarrying near 150
Ingersoll Gas Light Co., Ltd. 38
Ingles, John C. 147
Intercities Quarries Co. 30, 67, 30
International Molybdenum Co., Ltd.
Jamieson mine worked by 19
Molybdenite mine and operations of 19
Interprovincial Brick Co. of Canada, Ltd. 24
Irene lake.
Silver mining near 124
Irish, Mark 150

PAGE

Iron.
Assay, Provincial Assay Office 48
Cobalt area, with silver ores 223, 231, 234, 239, 240
Cobalt ores, determination of 202
Eastern Ontario 128
Folding, cause 182
photos showing 182, 183
Gunflint lake 185
Hunter island 163
Industry 16
Lount tp. 44
Production 2-4, 152, 153
total to end 1915 5
Statistics 15-17
Iron roasting plant.
Sault Ste. Marie 152
Iron arsenate. *See* Symplesite.
Iron formation.
Boston Creek gold area 252
Iron pyrites.
Boston Creek gold area, auriferous.. 252
Helen mine 69
In Cobalt area.
O'Brien mine 232
with argentite 208
with silver 234
Industry 34
Market 193
Mine accidents 53
Mines, producing 127
Molybdenite associated with 137, 138
Producers, list of 34-35
Production 34
Southeastern Ontario, report by Hopkins 192-199
map 193
Statistics 3-4
Timagami forest reserve 103
Irwin, Roland 69

Jack, Daniel 159
Jackman, H. E. 117
Jackson, A. W. 103
Jackson, D. I. 102
Jackson, F. 159
Jackson, P. C. 259
Jackson, Samuel 127
James, C. C. 105
James, R. H. 119
James Gow Lime Kiln, Ltd. 42
James Marshall Lime & Cement Works 28
Jamesonite, argentiferous.
Queensboro pyrite mine 197
Jamieson, J. A. 24, 143
Jamieson Bros. 135
Jamieson molybdenite mine.
Operations at, 1915 135
Purchased by Orillia Molybdenum Co. 134
Ref. 19
Jamieson Lime Co.
Operations of, 1915 143
Ref. 27
Jamieson Syndicate 17
Janes, D. A. 24

PAGE

Japan.
Matildite 233
Jarman pyrite mine. *See* Bannockburn mine.
Jasper lake.
Iron, analysis 184
Jasperson, B. 24, 37
Jaspilite.
Hunter island. 167, 170, 171, 172, 173, 180
Lake Superior iron region 185
Jean Petit copper mine 252
Jervis & Son, John 24
Johnson, H. L. 159
Johnson, James 24
Johnston copper claim 67
Jones, E. H. 69
Jones, James S. 37
Jones, Nelson 37
Jones, Thos. R.
Gen. superintendent Teck-Hughes mine 83
Jordan, D. 24
Jordan, Fred. A. 79
Jorgenson, Major Conrad 104
Jubilee gold mine 66
Junction Cut, Burlington Heights.
Gravel washing plant 157
Jupiter gold mine.
Operations, 1915 99
Jury, Dr. J. M. 67

Kaar, John 24
Kaeding, C. D. 85
Kaladar tp.
Gold mining 128
Karr, James 162
Karst, H. F. 102
Kearney, Edwin W. 81, 83
Keefer, C. H. 159
Keeley, D. E. 90
Keeley silver mine.
Operations at, 1915 126
Keewatin.
Boston Creek gold area 247
Cobalt area 110, 111, 119, 122
Gunflint lake, photo 188, 189
Hunter island 165, 166
Otter Track lake 184
Kehoe Bros. 143
Kellar, A. 18
Kelso, Alex. 103
Kennedy, Duncan 159
Kennedy, J. 150
Kennedy, R. C. 31
Kenora dist.
Mining land sold and leased 45
Kenora mining div.
Office statistics, 1915 43
Kent, W. 70
Kent Bros.
Mica trimming 133
Kent Bros. & J. M. Stoness 35
Kent gas field.
Gas line inspection 35
Producing wells, 1915 35-36
Production, 1915 39
Kenzie vein, R.A.P., gold mine.... 252, 254

PAGE
Kerfoot, George 159
Kerr, John 162
Kerr, Wm. 157
Kerr lake.
Dewatering of 11
Silver mining 111
Kerr Lake silver mine.
Accidents 58, 64
Löllingite 223
Operations at, 1915 111
Production, 1915 .....10, 11
Tax paid by 46
Kerr Lake Majestic Mines 111
Kerr Lake Mining Co. of New York.
Officers and holdings of 111
Kerr Lake Mining Co., Ltd.
Dividends of 6
St. Anthony mine operated by 68
Ref. 11, 111
Kettle, Robt. 162
Kettle, Wm. 162
Keweenawan.
Boston Creek gold area 251
Kidd, Walter R.
Molybdenite properties of 20
Kindy & Sons, D. 37
Kindy Gas Co., Ltd. 37
King Edward silver mine.
Operations at, 1915 117
Kingdon lead mine. *See* Galetta mine.
Kingston.
Mica trimming works 132, 133
Quarrying at penitentiary 31
Stone quarry operated by city 142
Kingston penitentiary.
Limestone quarry 142
Kingston Brick & Tile Works 24
Kingston Feldspar & Mining Co., Ltd.
30, 33, 131
Kingston Sand & Gravel Co. 29, 159
Kinmount, Lutterworth tp. 19
Kirby, A. G. 110
Kirby, Henry 162
Kirby, T. Sidney Co., Ltd. 31
Kirkegaard, Peter 122, 128
Kirkfield, Eldon tp.
Stone crushing works near 141
Kirkland Lake gold area.
See also Boston Creek gold area.
Accidents, number of 53
Cyanide practice 83
Gold mines 8
Inspector's report 81
Mine dividends 6
Molybdenite 21
Water power for 253
Kirkland Lake Gold Mines, Ltd.
Gold properties of 82
Ref. 105
Kirkland Lake Gold Mining Company, Limited 42
Kirkpatrick, S. F. 155
Kirkpatrick silver refining process.... 155
Kirkwood nickel mine.
Closed 74
Production, 1915 15

PAGE
Klopp, Elmer M. 162
Knife lake.
Water power 190
Knife Lake formation.
Hunter island 165, 166
Knight, C. W. 192, 242, 253
Knote, John M. 69, 152
Knoxwell Mining Co., Ltd. 42
Koebel, Joseph Z. 24
Kohler and Aikens 37
Kowkash gold area.
Gold discovered in 8
Min. Ref. 44
Report by Hopkins 264
Kruse Bros. 24
Kuhn, Henry J. 24

L. 13142-3-4 gold location. *See* Acme gold mine.
L. 1557 gold loc. 82
L. 1619 gold loc. 82
L. 1686-7-8 gold loc. 82
L. 1749-50-51 gold loc. 82
L. 1751 gold loc.
Development of 82
L. 1878 gold loc., Boston tp 247
L. 2000 gold loc., Boston tp. 251
L. 2022 gold loc. 81
L. 2194 gold loc. 81
L. 2571 gold loc. 81
L. 2631 gold loc., Boston tp. 255
L. 3687-8 gold loc. 85
L. 3689 gold loc.
Work done on 85
L. 4902 gold loc., Boston tp. 249
L. 5133 gold loc., Boston tp. 251
L. 5165 gold loc., Boston tp. 251
L.O. 313 silver location.
See also Bishop Silver Mines..
Operations at, 1915 124
La Belle Kirkland gold mine 8
La Belle Kirkland Mines, Ltd.
Gold mines of 82
Ref. 42
La Mine D'Or Huronia 259
La Rose silver mine.
Operations at, 1915 112
Production 10, 11
Tax paid by, 1915 46
La Rose Consolidated Mines Co.
Directors and mines of 112
La Rose Mines, Ltd.
Dividends of 6
Maidens-McDonald gold mine optioned by 97
Ref. 11
Work by, Boston tp. 254
Labine, Gilbert 85
Labour.
Brick industry, statistics 22
Gold mines 7
Gypsum industry 34
Lime industry 27
Petroleum industry, 1911-15 40
Salt industry, 1915 40
Lac La Croix.
Fish in 191

PAGE

Lacey mica mine.
Operations at, 1915 132
Ref. 1, 35
Ladore pyrite claim 194, 195
Lady Maud Lake Gold Mines, Ltd. ... 42
Laidlaw, Elliott C. P. 120
Laidlaw, Matthew 160
Laird, Alfred 160
Lake Erie.
Sand 146
Lake of the Woods region.
Keewatin rocks 166
Molybdenite 21
Lake Shore gold mine, Kirkland lake.. 8
Lake Shore Mines, Ltd.
Gold properties of 82
Lake Shore Natural Gas Co. 38
Lake Superior.
Pre-Cambrian rocks 166
Lake Superior iron area.
Jaspilite 185
Lake Superior Corp'n. (iron).
Tax paid by, 1915 46
Lally estate 31
Lalor, F. R. 37
Lalor & Vokes 37
Lamb, Alfred 37
Lamb, Walter B. 37
Lamble, B. C. 134
Lambton gas field.
Gas line inspection 35
Production, 1915 ..... 39, 40
Lambton oil field.
Production, 1915 40
Lamprophyre.
Boston Creek gold area 251
Lanark co.
Ornamental marble 29
Pyrite mining 194, 195
Lang, H. H. 119
Lang Bros. 25
Langmuir tp.
Gold mining 100
Larder Lake gold area.
Geology 246
Recorder's report, 1915 44
Larder Lake mining div.
Office statistics, 1915 43
Larioiere, Alex. 160
Larkin & Sangster 142
Larmouth, E. A. 121
Latour Lake.
Silver mining near 126
Laughlin, J. E. 158
Launders, Thomas 25
Laurentian.
Hunter island 165, 166
Laurentian gold mine 66
Laurentian Mica Co.
Mica trimming works 133
Lavas.
Boston Creek gold area 247
Lavoie, Alfred 27
Lawson, A. C. 166
Lawson, Alex. J. 90
Lawson, J. L. 108
Lawson silver mine.
Operations at, 1915 112

PAGE

Lawson tp.
Silver mining 125
Laxton tp., Victoria co.
Molybdenite mining 18, 137
Le Huray, Stephen J. 85, 112
Lead.
Boston Creek gold area 252
Cobalt area 208
in ores, determination of 202
Mining of, 1915 130
Production 4
to end of 1915 5
Lead pencils. *See* Pencils.
Leamington.
Sand and gravel washing plant near 156, 157
Leamington Brick & Tile Co. 25
Leather, T. E. 123
Leatherdale, R. W. 25
Lebel tp.
Copper 252
Gold mining 82, 83
Rocks 247, 250
Lecuier, Louis 159
Ledoux & Co. 48
Ledyard, L. W. 83
Ledyard iron mine 152
Leeds tp.
Granite 142, 144
Legislation (mining).
In 1915, notes by Rogers 5
Legree, Joseph 136, 137
Legree Bros. 19
Legree molybdenite mine.
See also Spain molybdenite mine.
Operations at, 1915 135
Ref. 138
Vein at 136
Leith, C. R. 247
Lennox, William B. 64
Lennox co.
Molybdenite 134
Leonard, Col. R. W. 73, 108, 154
Leslie, A. E. 27
Lethbridge Brick Co., Ltd. 25
Letson Gold Mines, Ltd. 42
Levack nickel mine.
Accidents 58, 64
Production, 1915 15
Lewis, Weston 156
Lewisohn, Adolph 111
Liedke, H. 20
Liesinger-Lembke Co. 37
Light, William 25
Lime.
Eastern Ontario 140-144
Producers, list of 27
Production 3, 4
Southwestern Ontario 144-151
Statistics 27
Lime, phosphate of. *See also* Apatite.
Production 4
Lime Agencies, Ltd. 27
Limehouse, limestone quarry 150
Limestone.
Building trade statistics 29
Calcite, Mich. 152

PAGE
For blast furnace flux 144
analysis 145
Hunter island, ferruginous 167
analysis 169
Quarries, list of 30
Quarrying, report on 140-151
Lincoln co.
Limestone 145
Lind, J. G. 150
Lindsay, Stephen 25
Lindsay municipality, Ops tp.
Gravel 160
quarry of 123
Lindsley, Stuart 124
Lingham, W. T. 25
Lipton, L. R. 123
Litt, Geo. S. 162
Little, M. C. H. 68
Little Nipissing silver mine.
Operations at, 1915 114
Little Salmon Lake pyrite deposit.
Description and operation 199
Ref. 194
Little Silver vein. *See also* Nipissing silver mine.
Development of 118
Little Vermilion lake.
Tamarac 191
Livermore, Robert 108, 111
Logan, Hugh 31, 148
Logan, John 25
Logan, Sir William.
Ref. to report on molybdenite, Laxton tp. 137
Logan limestone quarry.
Operations at, 1915 148
Ref. 146
Löllingite.
In Cobalt area 200, 223, 232
analysis 225, 226
diagram and photo 224
photomicrograph 225
Long Lake gold mine.
Operation and equipment 78
Long Lake Power Co. 253
Longford limestone quarry.
Officers of 148
Operations at, 1915 148
Longford Mills.
Limestone 148
Longford Quarry Co. 31
Longwell, Alex...73, 80, 109, 128, 143, 197
Loon lake.
Tamarac 191
Loring, Ernest M. 82
Loring, Frank C. 82
Lorrain S. tp.
Mining report 125
Lount tp.
Iron locations, 1915 44
Loughborough tp., Frontenac co.
Feldspar mining 131
Pyrite 194
Loughborough Mining Co., Ltd.
Ref. 35
Tax paid by, 1915 46
Lovelace, F. L. 105

PAGE
Lowes, Gordon 25
Lowery, Charles 149
Lubricating oil. *See* Oil.
Lucas, Robt. J. 162
Lucky Cross gold mine 82, 259
Lumby, J. A. 140
Lumsden, G. D. 27
Lumsden Mining Co.
Keewatin formation prospected by.. 121
Lutterworth tp., Victoria co.
Molybdenite mining 19
Lyman, R. H. 122
Lyndoch tp., Renfrew co.
Molybdenite mining 17, 19
Lyne, Harold 64
Lythmore.
Gypsum grinding plant at 151

Maberley.
Euxenite from 49
McAllister, J. E. 98
McAndrew, J. A. 127
McArthur, D. A. 104
McAulay, N. J. 43
McBroom, Geo. 102
McCamus, T. 90, 111
McCarthy, E. T. 99
McCarthy, Mike 64
McCluskey, H. C. 114
McConkey tp.
Mica locations, 1915 44
McConnell, Rinaldo 139
McCormick, John 148
McCormick limestone quarry.
Operations at, 1915 148
McCredie & Reid 25
McDonald, A. K. 160
McDonald, D. A. 160
McDonald, George E. 108
McDonough, Joseph 255
McDougal, N. 163
McElroy tp.
Rocks 249-251
Sand 251
McEwen lake, Hunter island 167
McFarlan, Wm. 124
McFarland, Matthew 64
McGibbon, Dugald 25
McGibbon, D. Lorne 85, 112
McGillis, Hugh 160
McGilvray, Jas. 27
McGugan (?) 185
MacGuire, John N. 106
McGuire, Patrick 160
MacGuire, Thomas D. 114, 117
McIlwraith pyrite mine.
Description and operations 195
Ref. 194
McIntosh, Hugh 160
McIntosh, J. A. 102
McIntyre, R. M. 149
McIntyre farm, Stephenson tp.
Feldspar on 131
McIntyre feldspar prospect 131
McIntyre gold mine.
Operations of, 1915 97
Statistics, 1915 .....7, 8

PAGE

McIntyre Extension Mines, Ltd.
McIntyre-Jupiter gold mines controlled by ... 97
Ref. ... 42
McIntyre-Jupiter Mines, Ltd. ... 42, 99
McIntyre-Porcupine gold mine.
Tax paid by, 1915 ... 46
McIntyre-Porcupine Mines, Ltd.
Capitalization and gold mines of ... 97
Directors of ... 98
Ref. ... 9
Mackan, J. J. ... 109, 154
McKane gold claim.
Leased by Beaver Mines, Ltd. ... 105
Ref. ... 8, 82
McKay, Alex. ... 148
McKay, Charles ... 160
McKay, Donald ... 128
McKay, Wm., Sr. ... 162
McKay & McPherson.
Limestone quarry of ... 148
MacKay Bros. ... 25
McKean, A. G. ... 123
McKelvie, A. A. ... 90
McKelvie, A. A. ... 111
McKenty pyrite mine.
Description and operation ... 198
Ref. ... 194
MacKenzie, Sir Alexander ... 165
Mackenzie, G. C.
Molybdenite concentrating tests by .. 134
McKenzie, J. F. ... 17, 134, 136
McKenzie Bros. ... 28
McKinley-Darragh-Savage silver mine.
Flotation process ... 12
Operations at, 1915 ... 113
Production ... 10, 11
Tax paid by, 1915 ... 46
McKinley-Darragh silver mine, Cobalt lake. *See* McKinley-Darragh-Savage.
McKinley-Darragh-Savage Mines of Cobalt, Ltd.
Directors of ... 114
Dividends of ... 6
Mines of ... 112
Ref. ... 11
McKinnon, Angus ... 160
McKune, C. S. ... 123
McLaren, G. R.
Operations by ... 69
McLaughlin, J. A. ... 140
McLaughlin, W. J. ... 128
McLean, David ... 160
McLeod, Norman R. ... 160
McLoughlin, John ... 25
McMahon, Frank ... 17
McMartin, John ... 94
McMillan, Arthur ... 160
McMillan, Fred. ... 28
McMillan, James ... 82, 142
McMillan, J. G. ... 66
McMillan, Ronald ... 160
McMillan limestone quarry.
Operations at, 1915 ... 142
McNaughton, George W. ... 133

PAGE

McNeill, W. K.
Assays by, 171-173, 180, 181, 184, 187, 259
Report as Provincial Assayer ... 47
McOuat, Walter ... 245
McPhail, Duncan ... 68
McPhail & Wright Construction Co., Ltd. ... 30
McPhee, D. A. ... 160
McPherson, Allen ... 148
McPherson, Benjamin ... 148
McQuire, H. F. ... 43
McRae gold mine ... 252, 258
McRann, Samuel ... 162
MacRow, Henry ... 142
McShedran, John ... 162
MacTernan, John ... 27
McVichie, J. A. ... 104
McWilliams, R. H. ... 150
Madoc.
Fluorite deposits near ... 136
Talc mining near ... 129, 130
Madoc tp., Hastings co.
Pyrite ... 194
Madoc Mining Co.
Goudreau pyrite mine operated by... 34
Magnesium.
Cobalt area ... 238
Magnesium arsenate.
Cobalt area ... 239
Magnetite. *See also* Iron.
Boston Creek gold area ... 252
Hastings co. ... 152
Hunter island ... 163, 172, 185
Magpie iron mine.
Location ... 16
Operations at ... 69
Ores smelted, character ... 152
Maher, William ... 160
Maidens-McDonald gold mine.
Operations at, 1916 ... 97
Maisonville tp.
Gold mining ... 85
Malleable Iron Works Company ... 160
Malloy, Thos. F. ... 124
Malloy Bros. ... 162
Maloney, John ... 25, 31
Manaton, C. H. ... 120
Mann Brick Co., Limited, John ... 25
Manufacturers' Corundum Co.
Accidents to employees ... 64
Operations of, 1915 ... 140
Ref. ... 32
Manufacturers' Natural Gas Co., Buffalo, N.Y. ... 38
Mapes-Johnston Mining Co., Ltd.
Mining operations ... 123
Officers of ... 123
Maple City Oil & Gas Co., Ltd. ... 37
Maple Mountain area.
Silver mining ... 126
Maple Sand & Gravel Company ... 160
Maps.
Gunflint Lake area ... 186
Hunter island, iron ore deposits ... 164
mining claims ... 168
Southeastern Ontario, pyrite deposits 193

PAGE

Marble.
Building trades, statistics 29
Quarries, list of 30
Quarrying of, 1915 140
Marcasite.
Cobalt area 232
March tp.
Molybdenite 21
Markgraf, E. J. F. 126
Markus, William 160
Markus, Wm., Ltd. 143
Marron, B. 153
Marshall, James 28, 31, 37, 148
See also James Marshall Lime & Cement Works.
Marshall, W. W. 25
Marshall limestone quarry.
Operations at, 1915 148
Martin, David 25
Martin, Edward 37
Martin International Trap Rock Co... 30
Martindale farm.
Gypsum on 151
Mason, Charles 25
Mason, W. T. 105, 122
Massey.
Copper, flotation process 12
Massey copper mine.
Operation and equipment 79
Ref. 14
Massey copper mine.
Operation and equipment 79
Ref. 14
Massey Station Mining Co. 79
Mataris, John.
Molybdenite in Sudbury Mng. Div. discovered by 44
Matawatchan tp., Renfrew co.
Molybdenite mining 19, 138
Mather and Beveridge.
Soapstone quarries 67
Matildite.
In Cobalt area 231
analysis 232
association with galena 233
Mattagami river.
Water power 7
Matthews, R. W. 139
Matthews & Foster 139
Matthews and McMahon 20
Matthews graphite mine.
Ore body at 139
Mattice, Herbert 160
Maurice, Adolph 64
Mawson, Agnes 162
Maxey, C. H. 156
Maxey, J. T. 156
Maynooth, Monteagle tp.
Graphite mining near 33, 139
Mazzutto, L. 59
Meaford Brick Co. 25
Medina Natural Gas Co., Ltd. 37
Meech, H. F. 139
Melville, David 123
Mercer Silver Mines, Ltd.
Silver mine and officers of 114
Ref. 42, 120

PAGE

Mercury.
Cobalt area 203, 204, 238
ores, determination of 202
Merkeley, Charles 160
Merkley Bros., Limited 25
Merner, J. J. 162
Merriam, W. N. 187
Merritton.
Calcium carbide works 32
Merritt's camp, Carp Lake.
Iron ore, contorted 179
photo 178, 179
Mersea tp.
Gravel 157
Mesabi iron ores.
Furnace charge, Steelton 152
Metal production. *See* Mineral Production.
Metal Refining Bounty Act 13
Metal Trades Safety Association.
Organization of 153
Metallography.
Cobalt ores. 201
Metallurgical works.
Accidents at.....52-54, 62, 63, 65
Metals Chemical, Ltd., Welland.
Arsenic refining 32
Bounties paid to, 1915 13
Officers and plant of 156
Ref. 12
Metcalfe, William 160
Meteor silver mine.
Operations at, 1915 114
Meteor Silver Mining Co., Ltd.
Mine of 114
Meteoric iron 201
Meter Inspection Act 35
Meters.
Natural gas 35
Metler, Stephenson tp.
Feldspar mining near 131
Meyer, Dr. Edward J. 82
Meyer, Frederick A. 8
Midfield Natural Gas Co., Ltd. 37
Mienwenhuyse, Victor 135
Mica.
Mining of, 1915 132
Parry Sound mining div. 44
Prices of 35, 132
Producers, list of 35
Production 3, 4, 35
Sydenham 1
Trimming and splitting, firms engaged in 133
Michigan Central Ry. limestone quarry.
Operations at, 1915 148
Michigan Central Ry. 31
Michigan-Ontario Mines, Ltd. 42
Michipicoten area.
Accidents, number of 53
Operating mines of 69
Mickle, G. R.
Report, as Assessor, natural gas industry, 1915 39
Report, Mining Tax collection 47
Mickle, Geo. T., & McKechnie, S. 37

PAGE

Mickle tp.
Silver mining 123
Miles, A. D. 69
Milky vein, Lacey mica mine 132
Mille Roches, Cornwall tp.
Limestone quarrying near 142
Miller, G. C. 85
Miller, George J. 101
Miller, Robert 160
Miller, Willet G. .....
192, 200, 242, 245, 247, 253
Miller, W. N. 43
Miller tp., Renfrew co.
Molybdenite mining 20
Miller Independence Mines, Ltd. 42
Gold mine 252, 256
Miller Lake-O'Brien silver mine.
Location 11
Operations at, 1915 124
Tax paid by, 1915 46
Millerton Gold Mines, Ltd.
See also Hollinger Consolidated Mines, Ltd.
Capitalization and mines of 96
Operations, 1915 97
Ref. 90
Milling (gold).
Porcupine area.
Dome mine 88
Dome Lake mine 90
Hollinger mine 93
McIntyre mine, costs 98
Milling (silver).
Cobalt area 108
Cobalt Lake mine 117
Nipissing mine 117
Penn-Canadian mine 120
Millington, R. C. 129
Mills, Geo. E. 25
Mills, James 162
Mills, S. Dillon.
Molybdenite property of 20
Milner tp.
Silver mining 124
Milton, Peter 28
Milton Pressed Brick & Sewer Pipe Co. 25
Mindoka.
Building stone near 253
Mine Centre, Rainy River dist.
Copper mining 14
Miner, J. T. 25
Mineral production, 1915.
Report by Rogers 3
Minerals.
Cobalt area, order of deposition..242-243
paragenesis 200-242
Miners' licenses 44
Mines Leasing & Development Co., Ltd. 9
Mining accidents.
Report by Sutherland 52
Mining costs. *See* Costs.
Mining Divisions.
List of 43
Mining lands.
Revenue 44
Mining Companies.
Incorporated, 1915, list of 41

PAGE

Licensed, 1915 43
Mining Recorders.
List and addresses of, 1915 43
Mining Corporation of Canada, Ltd.
See also Townsite-City and Cobalt Lake mines 10
Cobalt lake dewatered by 11
Dividends of 6
Mines of 114
Ref. 10
Royalties paid by 45-46
Mining Tax Act.
Revenue 46
Minnesota.
Iron ore deposits 165
Mitchell, Victor E. 112
Moffett, J. W. 105, 122
Molybdenite.
Boston Creek gold area 252
Industry 17
Mining of, 1915 134
Ontario deposits, report by Parsons.17-20
Production 3-5
Sudbury mining div'n. 44
Molybdic acid.
Production of 134
Mohr, Wm. S. 101
Mond Nickel Co.
Accidents 64
Bruce Mines purchased by 73
License, 1915 43
Operations, 1915 73
Production, 1915 15
Ref. 14
Tax paid by, 1915 46
Monteagle tp.
Graphite 139
Molybdenite 21
Montgomery, John 160
Montgomery, Joseph 122
Montreal river.
Cobalt water supply 11
Montreal River mining division.
Statistics, 1915 43
Mooney, John.
Molybdenite on farm of 20
Moody, Wm. 162
Moore, Chas. 125
Moore, E. S. 192
Moore, F. C. 125
Moore, George 160
Moore, Jos. 28
Moose Mountain iron mine.
Location 16
Operation and equipment 79
Moose Mountain, Ltd. 16
Moote, Melick and Lymburner 37
Morgan, J. W. 43
Morin, (?) 19
Morley, Walker 25
Morley & Ashbridge 25
Morrissette tp.
Gold mines 81
Morrison, Jos. H. 160
Morrison, J. W. 81, 82
Morrison, M. J. 126
Morrison, Thomas 140

PAGE
Morrison, W. E. 162
Morrow, Jas. A. 49
Morse Porcupine Syndicate, Limited.. 42
Mosure, Isaac E. 104
Mount Nickel mine.
Accident 58, 64
Location 14
Operation and plant 77
Production, 1915 15
Mount St. Patrick.
Molybdenite 17
Mount St. Patrick Molybdenite Mines, Ltd. 42
Mowat, H. M. 77
Mud Turtle lake.
Molybdenite on shore of 137
Ref. 18
Mumford, W. J. 76
Munger, A. H. 139
Munich, A. G. 131
Munro, D. W. 25
Munro tp.
High-grade gold ore 44
Munro Consolidated Gold Mines, Ltd. 42
Munroe, John L. 162
Munsell, Eugene & Co.
Mica trimming 133
Murphy, John A. 85
Murphy, J. S. 31
Murphy, William 160
Murray, Major J. A. 120
Murray, J. C. 19, 136
Muskoka dist.
Feldspar 131
Muurling, I. J. R. 98

Nancy Helen silver mine.
Royalties paid by 46
Nanticoke Natural Gas Co., Ltd., The 37
Napanee Brick & Tile Co., Limited.. 25
Naphtha.
Statistics, 1911-1915 40
Narraway, Chas. 129
National Fire Proofing Co. 25
National Graphite, Ltd.
Operations of, 1915 139
Ref. 33, 42
National Mines, Ltd.
Officers 117
National Portland Cement Co. 28
Natural gas. *See* Gas, natural.
Natural Gas Co., Ltd. 37
Nayler & Son, F. W. 25
Near, A. E.
Oil and gas inspector 35
Report on Welland gas field, 1915 .. 36
Neault, P. C. 135
Neelands, E. V.
Ref. 108
Silver Queen mine leased by 122
Neilly, Balmer 119, 120
Nelles, N. 103
Nelles Corners Gas Company 38
Nepean tp.
Limestone 143
Nesbitt, E. W. 112
Nesbitt, Robert A. 160
Nesbitt, Wallace 85
New, Edward 25, 160
New York Graphite Co.
Amalgamated with National Graphite, Ltd. 139
Newray Mines, Limited 42
Next Man lake, Hunter island.
Iron deposits 174-176
analysis 175
photo 174, 175
Niagara limestone.
Evanturel tp. 246
Niagara Natural Gas & Fuel Co., Limited 37
Niagara peninsula.
Gas well inspection 35
Gravel producers 158-162
Niagara Sand Corporation 29
Niagara tp.
Limestone 149
Nickel.
Bounties on 13
In Cobalt area 214, 216, 223
ores, determination of 202
from cloanthite 221
Industry 15
Mines, Inspector's report on 77
Production 3, 4
Total to end of 1915 ..... 2, 5
Taxes paid by mines 46
Nickel oxide.
Bounty on 13
Production 3, 4, 5, 12
Refining 153-156
Nickel sulphate.
Produced at Welland 156
Niccolite.
Cobalt Lake silver mine 115
In Cobalt area 209, 211, 231
analysis 217
etching methods 215
isomorphous elements with 240
microscopic examination of 217
micro-structure 212
photomicrographs 213, 214, 230
Niccolite-breithauptite.
Cobalt area 241, 242
Nicholas, Gideon 160
Nicol, J. C. 97
Nichols, J. C. 69
Nichols, H. 160
Nichols, W. H. 78
Nichols Chemical Co., Ltd.
Purchasers of pyrite 34
Pyrite mine of 192
Ref. 34, 194, 196
Nicholls, J. C. 59
Night Hawk river.
Gold mining 102
Nipissing dist.
Mining land sold and leased 45
Nipissing nickel mine 58
Nipissing silver mine.
Accidents 64
Operations at, 1915 117-119
Production 10, 11
Tax paid by, 1915 46

PAGE

Nipissing Mining Co., Ltd.
Dividends of 6
Officers of 119
Ref. 11
Report of, 1915 117
Teck-Hughes option relinquished by. 83
Norfolk Gas Company, Ltd. 37
Norfolk co.
Natural gas 39
Norland.
Molybdenite at 17
North American Chemical Co., Limited 41
North Crosby tp.
Molybdenite 21
North Lake.
Iron, analysis 187
Route to Hunter island iron area... 163
Trees 191
North Lanark Marble & Granite Quarries 30
North Shore Gas Co., Ltd. 37
North Thompson gold mine.
Operations, 1915 99
Ref. 8
North Thompson (Associated) Gold Mine, Ltd.
License, 1915 43
North Thompson Gold Mines, Ltd.
Directors and property of 99
Northern Canada Power Co., Ltd. 7
Northern Customs Concentrators, Ltd.
Officers of 119
Operations, 1915 119
Northern Ontario Light & Power Co. 253
Northampton Mining Co., Limited.... 42
Northern Ontario Light & Power Co.
Extensions proposed 253
Northern Pipe Line Co., Ltd. 38
Northern Pyrites Company, Ltd.
Mine operations of 67
Ref. 34
Northwestern Gas Company, Limited.. 37
Norton, Alsey 25
Norton, A. 147
Norton, David 25
Norton, John 160
Norton, T. W. 25
Nova Scotia silver mine.
Native silver, analysis 203
No. 2 nickel mine.
Accident 64
Location 14
Operations, 1915 73
Production, 1915 15
No. 2 silver mine.
See also Right of Way Mines.
Operations at, 1915 121
No. 3 silver mine.
See also Right of Way Mines.
Operations at, 1915 121

Oakes, Harry 81, 82, 83
Oakville Pressed Brick Co. 25
O'Brien, M. J. ..11, 17, 119, 136, 138, 155
O'Brien molybdenite claim.
Vein on 136
O'Brien silver mine.
Accidents 64

PAGE

Argentite, analysis 208
Arsenopyrite 227
analysis 228
Galena 208, 232
Glaucodot 230
Operations at, 1915 119
Polybasite crystals 234
Production 10, 11
Proustite 233
Royalties paid by 45
O'Briens-Greenfield.
Molybdenite mining operations of .. 18
O'Connell, C. A. 84
O'Connell, J. T. 160
O'Connor, D. D. 145
Odell & Sons, William 25
Oderdike farm, Sheffield tp.
Molybdenite found on 135
Ogden tp.
Gold mining 90
Ogilvie, Shirley 112
Ogishke formation.
Hunter island 165, 166
Ogishkemuncie lake, Minn. 166
Oil.
Bounty 39
Flotation process 12
Illuminating, production, 1911-15 40
Industry 39
Lubricating, production, 1911-15... 40
Refining statistics, 1915 40
Price, 1915 39
Production, 1911-1915 40
1915 ..... 3, 4
Industry, 1915 .....39, 40
Oil Flotation process. *See* Flotation Process.
Oil wells.
Enniskillen and Petrolia, depth attained 35
Statistics, 1915 40
Oil Springs.
Natural gas production 39
Oil Springs Oil & Gas Co., Limited... 37
O'Leary, C. A. 106
Oliphant, A. E. 141
Oliver, D. G. 123
Oliver, S. J. 149
Oliver pyrite claim. *See* Canada pyrite mine.
Oliver-Rogers limestone quarry.
Operations at, 1915 149
Ref. 147
Oliver-Rogers Stone Co. 31
Oliver Silver Mining, Ltd. 125
Oliver's Ferry, Rideau lake.
Mica mining near 133
Ollmann Bros. 25, 29, 160
Olympia gold mine 7, 68
Olympia Gold Mining Co., Limited.... 9
Oneida tp.
Gypsum 151
Oneida Lime Co., Ltd. 28, 29
Onondaga oil field.
Production, 1915 40
Onondaga Oil and Gas Co., Limited... 37
Ontario.
Nickel (metallic) produced in 15

PAGE
Ontario marble quarry.
Operations at, 1915 140
Ontario Limestone & Clay Co., Ltd. .. 28
Ontario Marble Quarries, Ltd.
Quarries and plant of 140
Ref. 30
Ontario National Brick Co. 25
Ontario Paving Brick Co. 25
Ontario Portland Cement Co. 28
Ontario Rock Co.
Officers of 143
Operations of, 1915 142
Ref. 30
Ontario Sand Co. 160
Ontario Sewer Pipe Co. 27
Ontario Sulphur Mines, Limited.
Pyrite mine of 197
Ref. 194
Ophir silver mine.
Operations at, 1915 119
Ophir Cobalt Mines, Ltd.
Officers and silver mine of 119
Ore sampling. *See* Sampling.
Ore Chimney Mining Co., Ltd.
Mining operations, 1915 129
Officers of 129
Ore Extension Mining Co. 129
Ore Mountain Mining Co., Ltd.
Operations of, 1915 129
O'Reilly, T. E. 25
Orillia.
Limestone quarrying near 148
Molybdenite reduction works 134
treatment charges 134-5
Refinery 153
Orillia Molybdenum Co.
Jamieson claim acquired by 135
Officers of 134
Operations of, 1915 134
Ref. 42
Smelter of 153
Orr, Fred O. 17, 136
Molybdenite claim 136
Orser, S. H.
Mica mining operations 133
Ref. 132
Oscar Daniels Co.
Trap quarry of 80
Oshawa Corporation.
Gravel quarry 159
Oswald, H. O. 106
Ott Brick & Tile Co. 25
Ottawa.
Limestone quarrying near 143
Mica trimming 133
Ottawa Brick Mfg. Co. 25
Otter Track lake.
Iron deposits 182
Photo 183
Owen Sound.
Limestone, agricultural demand 144
quarrying 146, 148, 149
Owen Sound Brick Co. 25

P. 6899-6900 gold loc. 90
Pacaud tp.
Agricultural land 253
Building stone 253
Garnets 250
Gold 256,-258
Iron pyrites 250-252
Rocks 250, 251
Painter, Robt. K. 78
Palladium.
Production 4
Total to end 1915 5
Palmer, J. G. 67
Palmer, R. N. 77
Palmer & Bastin 201, 205, 221
Palmer pyrite claim. *See* Davis claim.
Papassimakes, John 254, 259
Papassimakes gold mine, ... 252
Boston Creek 252
Goldfish lake 260
Paragon Silver Mining Co., Ltd.
Mining operations and officers of .. 123
Parham.
Feldspar grinding mill at 33
Parish, Thomas 162
Paristone wall plaster 151
Park, Hugh 119
Park, John S. 162
Parker, W. R. P. 106
Parkhurst, A. J. 151
Parks, H. W. 25
Parks, Dr. W. A. 246, 252
Parks & Sons, R. B. 28
Parolin, Giovanni 64
Parry Sound.
Blast furnace 153
Parry Sound dist.
Mining land sold and leased 45
Parry Sound mining div.
Office statistics, 1915 43
Recorder's report, 1915 44
Parsons, Arthur L.
Report by, on Hunter island and Gunflint lake iron deposits 163-191
Report by, on Ontario molybdenite deposits 17
Ref. 193, 215, 233, 234
Pascoe, Oliver 160
Pashler, L. J. 123
Paterson, Mark J. 17, 19, 136
Paterson molybdenite claim.
Operations at, 1915 136
Patno, J. G. 139
Patterson, C. V. 106
Patterson, Thomas 160
Patterson shaft, Adanac silver mine.. 104
Paxton & Bray 25
Pay Ore Mines, Ltd. 129
Pearceite.
To distinguish from polybasite 235
Pearl Lake gold mine 8
Pears & Sons, James 25
Pears, William 25
Peerless Brick & Tile Co. 25
Peat.
Production 4
Peek, R. L. 154
Pegmatite.
Molybdenite in 19, 20
Pacaud tp. 250

PAGE
Pelee Island.
Limestone quarrying 148
Pellatt, Sir Henry M. ..17, 19, 98, 117, 120
Pembroke.
Limestone quarrying 143
Pembroke Brick Co. 25
Pencils.
Graphite for 139
Penfield & Goldschmidt 235
Penn-Canadian silver mine.
Native silver, analysis 203
Operations at, 1915 120
Production 10, 11
Symplesite 236
Tax paid by, 1915 46
Penn-Canadian Mines, Limited.
Officers of 120
Ref. 11
Perkins, George A. 31
Perry, W. W. 106
Perry lot, Huntington tp.
Fluorite 130
Perth.
Mica mining near 133
Peru.
Matildite 233
Peterboro' Corporation.
Gravel quarry of 159
Peterson, L. 126
Peterson lake.
Hydraulicing near 118
Peterson Lake silver mine.
Operations at, 1915 120
Peterson Lake Silver Cobalt Mining Co., Ltd. *See also* Mercer Silver Mines, Ltd.
Directors of 120
Dividends of 6
Mining by 120
Petroleum. *See* Oil.
Petrolia oil field.
Gas line inspection 35
Petrolia Utilities Co., Ltd. 38
Petty Charles 25
Pewabic.
Indian name for iron 177
Pewabic lake.
Iron deposits 177
Phillips, Robert 129
Phillips, Thomas 25
Phinn, George E. 25
Phosphate of lime 4
Pickerel lake.
Dewatering of 117
Ref. 11
Pig iron. *See* Iron.
Pillow lava flows.
Boston Creek gold area 247
Pilon, A. 25
Pine, banksian.
Hunter island iron region 191
Pine, red.
Hunter island iron region 191
Pipestone portage, Pipestone bay, L. of Woods.
Soapstone quarry 67
Pittsburg-Lorrain Syndicate 125

PAGE
Platinum.
Assays, Provincial Assay Office 48
Determination of 48
Production of 4
Total to end of 1915 5
Properties of 49
Poillon, H. A. 102
Point Anne limestone quarry.
Operations at, 1915 140
Point Anne Quarries, Ltd.
Officers of 143
Operations of 143
Ref. 31
Poirier, C. H. 107
Poirier, Emerie 28
Policiuk, George 64
Polybasite.
In Cobalt area 208, 234
analysis 236
drawing 235
Pomeroy, Robt. W. 83
Ponsford, A. E. 25
Ponton, Douglas 17, 18
Poole, T. A. 28
Poplar.
Hunter island iron region 191
Porcupine gold area.
Accidents, number of 53
Dividends mining companies 6
Gold mines, statistics 7, 8
Gold mining, Inspector's report on.. 85
Milling practice 88, 90, 93
Pillow lava 261
Quartz porphyry 251
Porcupine mining div.
Office statistics, 1915 43
Recorder's report 44
Porcupine Crown gold mine.
Operations, 1915 100
Ref. 5
Statistics, 1915 7
Tax paid by, 1915 46
Porcupine Crown Mines, Ltd.
Directors and mine of 100
Dividends of 6
Ref. 9
Porcupine Excelsior Mining Company, Ltd. 47
Porcupine Imperial gold mine.
Operations, 1915 100
Porcupine Miracle gold mine.
Operations at, 1915 101
Porcupine Miracle Mining Co., Ltd.
Directors of 101
Mine of 100
Porcupine Imperial Mining Co., Ltd.
Mine of 100
Porcupine Pet gold mine 7
Porcupine Pet Mining Company 9
Porcupine Porphyry Hill Mining Company 9
Porcupine Vipond gold mine.
Operations at, 1915 101
Porcupine Vipond Mines, Ltd.
Mines of 101
Officers of 102
Ref. 9

PAGE

Porquis Junction.
Nickel mining near 103
Port Alma.
Gas pumping plant 36
Port Arthur mining division.
Office statistics, 1915 43
Recorder's report, 1915 44
Port Arthur Sand-lime Brick Co. 25
Port Colborne.
Blast furnace 152
Limestone quarrying 145
Port Colborne-Welland Natural Gas Company 38
Port Colborne-Welland Natural Gas and Oil Co., Ltd. 37
Port Credit Brick Co. 25
Port Dover Brick & Tile Co. 25
Porter, Thompson 160
Port Elmsley.
Graphite mill at 139
Portland tp.
Feldspar mining 131
Portland cement. *See* Cement.
Port Rowan Natural Gas Co., Ltd. 38
Portsmouth.
Limestone quarrying 142
Porphyry.
Carp lake 179
Goodfish Lake gold area 261
Porphyry Hill gold mine 7
Potash.
From feldspar 33, 132
Pottery.
Industry 22
Production 3, 4
Potvin gold claim 260
Poutanen, Henry 64
Powerful Development Co.
Mining operations of 125
Officers of 125
Predmore, H. S. 129
Pre-Cambrian.
Boston Creek area 246
Goodfish Lake gold area 260
Porcupine gold area 261
Premier-Langmuir gold mine.
Operations at, 1915 102
Premier-Langmuir Mines, Ltd.
Directors and barite mine of 102
Preneveau, Belmont tp.
Trap rock quarrying at 142
Prescott Corporation.
Gravel quarry of 159
Preston, S. R. 145
Price, John 25
Prices, Ltd. 25
Prince Edward co.
Limestone 143
Princess silver mine.
Operations at, 1915 112
Pringle, Frank 160
Producers Natural Gas Company, Limited 38
Prosser, Edward 160
Proustite.
Cobalt area, analysis 233
Provincial Assay Office.
Annual report by W. K. McNeill ... 47
Tariff of fees 49

PAGE

Provincial Natural Gas & Fuel Co.
Operations and production, 1915.... 36
Provincial Natural Gas and Fuel Co.
Statistical records of 39
Ref. 38
Provincial Stone & Supply Company, Ltd. 42
Pullen, Capt. E. F. 14, 103
Pullen, Frank 103
Pulpstone wall plaster 151
Purdy, Walter 122
Puslinch tp.
Limestone 149
Pyne graphite mine. *See* Globe mine.
Pyrargyrite.
Cobalt area 234
Pyrite. *See* Iron Pyrites.
Pyroxenite.
Laxton tp., associated with molybdenite 137
Renfrew co., molybdenite mines 19
Pyrrhotite.
Lanark co., associated with pyrite 196, 197
Molybdenite associated with 137

Quarries.
See Granite, Limestone, Marble, Quartz, Sandstone, Trap.
Accidents 52-54
Dill tp. 72
Eastern Ontario 140-144
Hunter island iron formation .....
165, 167, 173, 176, 181, 185
Industry, statistics 29, 30
Inspector's report on 80
Lists of 30
Metallurgical flux 30
Millerton gold mine, character of .. 97
Molybdenite in vein of 137
Production 3, 4
Southwestern Ontario 144-151
Quartz.
In Cobalt area 239
with argentite 208
with chalcocite 209
List of quarries 30
Production and industry 29
With pyrite, Lanark co. 195, 196
Quartz, Ont.
Quartz quarry 72
Quartz porphyry.
Boston Creek gold area 251
Lake of the Woods region 166
Quartz syenite.
Pacaud tp. 250
Quartzite.
East Neebish island 80
Queensboro pyrite area 192
Queensboro pyrite mine (Blakely).
Description and operation 197
Operations, 1915 128
Ref. 194
Queenston Quarry Company.
Limestone quarry of 149
Ref. 31
Quetico Provincial Park 191
Quilty, Thomas 19

PAGE
Quinlan & Robertson, Ltd. 31, 141
Quinn, John S. 160

R-305 iron claim, Hunter island.
Iron ore, analysis 181
R-343 iron claim 169
Radium.
Assays for, Provincial Assay Office.. 49
Raglan tp., Renfrew co.
Corundum 32
Molybdenite mining 20
R.A.P. Mining Co. 254
See also Kenzie Veins.
Rainy lake.
Fish 191
Iron deposits 165
Keewatin rocks 166
Water power near 188
Rainy River dist.
Iron deposits 184
Mining land sold and leased 45
Rama tp.
Limestone 148
Rammelsbergite.
In Cobalt area 200, 241, 228
analysis 229
photomicrograph 230
Rand Syndicate.
Pyrite mine of 103
Randall, Charles A. 85
Ransford, John 41
Ransom, H. Burton 101
Rawlins, J. W. 69
Rayner, George W. 80, 143
Rea Consolidated gold mines, Ltd.
Dividends of 5, 6
Rea (Mines Leasing Co.).
Statistics, 1915 7
Recorders. *See* Mining Recorders.
Red River Settlement 188
Reed, Mrs. A. 26
Reese, C. E. 122
Reeve-Dobie silver mine.
Operations at, 1915 125
Refineries.
Report on, 1915 152
Regah Natural Gas Company 38
Reid, Fenton 31
Reid, Fraser D. 109
Reid, John 109
Reinville, Adolphe 160
Reliance silver claim.
Optioned to Peterson Lake Mining Co. 120
Relief Gas Company, Ltd.
Operations and production, 1915 .. 36
Ref. 38, 42
Renfrew.
Limestone quarrying 143
Renfrew co.
Graphite 33, 138
Marble 140
Molybdenite 134-136, 138
mining 19
Pyrite 127
Renfrew Molybdenum Mines, Ltd.
Mine and operations of 19

PAGE
Officers of 135
Reynolds farm, near Verona.
Feldspar mining on 131
Reynolds feldspar mine 33, 131
Rhyolite.
Beatty tp. 247
Rhyolite porphyry.
Goodfish Lake area 260
Rice, George A. 26
Rice, Geo. A., & Sons 162
Rice, John 160
Rice, J. A. 126
Rice, Thos. B. 126
Richards, Benjamin 94
Richards, F. B. 128
Richards, Jos. 162
Richardson, Chas. A. 104, 125
Richardson, C. G. 156
Richardson, H. W. 132
Richardson, Thomas E. 136
Richardson & Son, James 26
Richardson feldspar mine.
Fire at grinding plant of 131
Richardson molybdenite claim.
Development of 136
Vein 137
Rideau Canal Supply Co.
Operations of, 1915 143
Ridgeway, Bertie tp.
Limestone quarrying near 145, 149
Riehl, George 162
Ries, John 26
Right of Way silver mine.
Location 11
Royalty paid by 46
Right of Way Mines, Ltd.
Directors of 121
Dividends of 6
Mining by 121
Ref. 11
Rilett, David 26
Ritchie, S. S. 90, 111
R.L. 402 silver location.
Exploration of 118
Roadhouse, Margaret 162
Roaf, James, R. 103
Robbins, P. A.
General Manager, Hollinger gold mine 94
report of 91
on Acme mine 95, 96
Millerton mine 97
Robbins, R. W. 94
Roberts tp.
Molybdenite discovered in 44
Robertson Co., Ltd., D. 28, 31
Robertson, D. D. 149
Robertson, Estate James, Ltd.
Lead mining by 130
Robertson, J. F. 73
Robillard, R. E. 144
Robillard & Son, H.
Limestone quarry of 143
Ref. 28, 31
Robinson, Albert 160
Robinson, Alfred 160
Robinson, H. S. 82, 121, 123

PAGE
Robinson, Richard 160
Robinson, William 160
Robinson, Wm. J. 162
Robinson Road Gas Co. 38
Rochester silver mine.
Operations at, 1915 121
Purchased by Trethewey Mining Co. 123
Rockwood.
Limestone quarrying 147
Roddy & Monk 31
Rogers, George R. 124
Rogers, R. P. 109
Rogers, W. R.
Statistical Review by 1-51
Rogers, F., & Co.
Limestone quarry of 149
Ref. 31
Rogers lot, Huntington tp.
Fluorite 130
Rollins, John 162
Rolph, Alfred 67
Rolston, James 38
Romanka, Harry 64
Rood, Hayden 79
Rose, John 20
Rose & Patterson 38
Rose Hill Natural Gas Co. 38
Rosendale, George 124
Ross, J. G. 109
Ross tp.
Molybdenite 136
Rothwell, T. E. 48, 259
Round lake, Blanche river.
Agricultural lands 251
Rocks 249
Rove Lake series.
Gunflint lake 185
Rowe, Wm. 78
Rowntree, Josiah L. 26
Royal Ontario Museum of Mineralogy. 200
Royalties.
Revenue from 45
R.S.C. 79 silver location.
See also Mapes-Johnston Mining Co.
Operations at, 1915 127
Rubel Bros. 31
Rubicon Silver Mining Co., Ltd.
Mining operations of 126
Officers of 126
Rudd, John 160
Rumble, Fred. 102
Rumble, Harry 160
Russell, Alex. 110
Russell, A. J. H. 17, 18, 137
Russell, Joseph 26
Russell molybdenite claim.
Operations at, 1915 137
Russell Brick & Tile Co., Ltd. 26
Ryckman, Edmund B. 124

Sable River Copper Co., Ltd.
Organized to operate Massey mine.. 79
Ref. 14, 42
Safflorite (Cobalt diarsenide).
Cobalt area 225, 226, 232
Saganaga lake.
Granite 166
Trees 191
Water power, photo 190
Saganagons lake.
Granite 166
Iron deposits 167, 176, 184
analysis 185
St. Anthony gold mine 68
St. Catharines.
Natural gas supplied to 36
St. David limestone quarry 149
St. David Sand Company 161
St. Joseph island.
Trap quarry 80
St. Marys.
Limestone quarrying 150
St. Marys Horse Shoe Quarry, Ltd. .. 31
Operations at, 1915 150
St. Marys Portland Cement Co. 28
Officers of 150
Plant and quarry of 150
Salt.
Producers, list of 41
Production and industry, 1915 ..3, 4, 40
Salter tp.
Copper mining 79
Saltfleet tp.
Limestone 145, 151
Sampling.
Coniagas reduction works 154
Deloro reduction works 154
Sancton, Arthur H. 94
Sand.
Hunter island 165
Industry 3, 4, 28-29
Lake Erie 146
Leasing regulations 28
McElroy tp. 251
Producers, list of 29
Washing plants 156
Sand-lime brick.
Statistics 22
Sandstone.
Esquesing tp. 146, 147
Industry, 1915 29
Quarries, list of 30
Sandy falls, Mattagami river 7
Sarnia Gas & Electric Light Co., Ltd. 38
Sarpedon lake.
Forest fires 163
Iron deposits 165
Iron ores 176, 177
Photo 176
Rocks 167
Water power 190
Sault Ste. Marie.
Blast furnace and roasting plant... 152
Sault Ste. Marie mining div.
Office statistics, 1915 43
Sauve, Emmanuel 58, 64
Schaefer Brick Co. 26
Schist.
Lake of the Woods region 166
Molybdenite in 138
Schist: crystalline.
Lanark co., pyrite deposits 196
Schultz Bros. Co., Limited 26
Schumacher, F. W. 102

PAGE
Schumacher gold mine.
Operations at, 1915 102
Ref. 7, 8, 44
Schumacher Gold Mines, Ltd.
Directors and gold mine of 102
Ref. 9
Schwartzentrauber, Jacob 162
Schwendiman, F. W. 151
Scorodite.
Cobalt area, analysis 240
Scott, Harold G. 161
Scott, James M. 26
Scott, John.
Oil and gas inspector 35
Report on oil wells 40
Scott, J. W. 120
Scott Bros. 133
Scott mica mine.
Operations at, 1915 133
Seager, Sidmore 123
Sebastopol tp., Renfrew co.
Molybdenite mining 20
Segsworth, R. F. 106, 114, 122
Segsworth, W. E. 106, 114, 122
Sellwood.
Iron mining 79
Seneca-Superior silver mine.
Operations at, 1915 121
Production 10, 11
Seneca-Superior Silver Mines, Ltd.
Dividends of 6
Mining operations of 121
Officers of 122
Ref. 11, 120
Tax paid by, 1915 46
Sepprell, J. G. 136
Sericite schist.
Lake of the Woods region 166
Serpentine.
Boston tp. 249
Sesekinika.
Gold mining near 85
Sewer pipe.
Industry and statistics 22, 27
Makers, list of 27
Production 3, 4
Seybold, E. 121
Seymour Power Co. 198
Seymour Power and Electric Co. 196
Shafts.
Accidents in 54
Shale.
Brick industry, statistics 22
Excavations inspected 158-162
Shamrock Consolidated Mines, Ltd.... 42
Mining operations of 122
Officers of 122
Shane, J. S. 141
Shanedarr Mining Company, Ltd. 42
Shanette, Alexander 161
Shanks, James 160
Shannon, C. G. 20
Sharpe, A. L. 74
Shaw, John W. 106
Sheffield molybdenite claim.
Operations at, 1915 137
Sheffield tp.
Molybdenite 17, 18, 135, 137

PAGE
Shepherd, Harry 43
Molybdenite, Sudbury dist., discovered by 43
Sheppard, H. E. 43
Sheppard, W. J. 98, 123
Sherkston.
Limestone quarrying 146
Sherman, Wm. 162
Sherrill, Chas. L. 90, 111
Sherwood, Geo. E. 160
Shields, Wm. J. 124
Shiels, Charles 79
Shillington, R. T. 102, 104
Shipman pyrite claim 194, 195
Shock, H. L. 141
Shook, G. L. 153
Short lake.
Dewatering of 117
Ref. 11
Showler, Geo. 162
Sibley, Harper 114
Sibley, Hiram W. 114
Sidener, Prof. C. F. 170, 171, 173, 175
Siderite.
Hunter island 167, 176, 177
analysis 169
Magpie mine 69
Sidney H. Orser Mica Co. *See* Orser, S. H.
Siemon, Conrad 162
Silica.
Hunter island iron, percentage 169
Silicate Brick Co. of Ottawa, Ltd.... 26
Silver.
Assays, Provincial Assay Office 48
Boston Creek gold area 252
In Cobalt area.
determination 202
native, analysis 203
photo 204
refining 155, 156
sampling 154
Industry 9
Porcupine area, in barite vein 102
Production 3, 4
to end 1915 5
Price 9, 10
Recovery from gold mines 7
Refining 153-156
Taxes paid by mines, 1915 46
Silver lake.
Silver mining near 123
Silver, native.
Cobalt area 205, 209, 212, 232, 239
analysis 203
deposition 243
photomicrograph 214, 215
Silver Bar silver mine.
Vein, diagram 242
Silver Leaf silver mine.
Location 11
Silver Queen silver mine.
Location 11
Operations at, 1915 122
Sinden, L. H. 26
Sipprell, J. G. 134
Sipprell, J. H. 26

PAGE
Skill, A. 43
Skobba, A. J. 125
Skutterudite 201
Slag.
For concrete making 145
Slate.
Boston Creek gold area 247, 249
Slate lake, Hunter island 167
Sleeman, Philip 161
Sloan, Robert 100
Sloan, W. W. 106
Sloan pyrite claim.
Description and operations 195
Ref. 194
Smaltite.
Cobalt area 219, 234
isomorphous elements with 240
photo 206
photomicrograph 214, 220, 231
Smaltite-chloanthite.
Cobalt area 201, 241, 242
Smelters.
Coniston, operations 73
Copper Cliff 69
Orillia, molybdenite 134, 135
Quartz used as flux by 30
Smith, Arthur 160
Smith, Allan G. C. 26
Smith & Sons, Alex. 26
Smith, C. E. C. 85
Smith, Dan 85
Smith, Edward 132
Smith, Dr. E. P. 122
Smith, G. R. 29
Smith, G. T. 43
Smith, John 160
Smith, John S. 28
Smith, J. W. 162
Smith, Sidney 104, 112
Smith, Wm. 162
Smith, W. H. C. 163, 165, 167, 180
Smith, W. N. 77
Smith, W. W. 26
Smith Bros. 26, 162
Smith lake, Boston and Pacaud tps.
Trees 253
Smith-Labine gold mine.
Tellurides 85
Smithers, Wm. 162
Smoot, A. M.
Platinum determination, method of. 48
Smooth Rock lake, Manitou region.
Molybdenite 21
Smythe, H. V. 68
Snake lake.
Molybdenite mining at 137
Snead, J. N. 139
Snelgrove & Teer 26
Snively, F. L. 38
Snooks pyrite claim.
Description and operation 199
Ref. 194
Snowden, Thomas 161
Soapstone.
Pipestone portage 67
Soda-smelting furnace.
Lining for 67
PAGE
Sodium sulphide.
Silver precipitant 118
Solvay Process Co.
Limestone quarry of 144
Somerville, A. E. 102
Somerville tp.
Limestone 140, 141
Molybdenite 21
Soo Dredging & Towing Co. 29
Soudan iron formation.
Hunter island 165, 166, 167
Southern Ontario Gas Co. Ltd. 38
pumping plant 36
Southworth, Thos. 155
Spain, W. J. 17, 19, 135, 137
Spain molybdenite claim.
Operations at, 1915 138
Sparham, Andrew 38
Spaulding, Willis M. 90
Specularite.
Boston Creek gold area 252
Speiss.
Refining practice 154-156
Spence, J. H. 114
Spratt, Matthew 18
Spratt farm, Sheffield tp.
Molybdenite found on 135
Springtown, Bagot tp.
Molybdenite 19
Springvale Oil & Gas Co., Ltd..... 38
Sproat, William M. 26
Spruce.
Hunter island iron region 191
Spry, W. L. 43
Stalker pyrite claim.
Description and operation 199
Ref. 194
Stamford Sand Company 161
Standard Brick Co. 26
Standard Chemical, Iron & Lumber Co. 28
Limestone quarry at Eganville 141
Standard Crushed Stone Co.
Officers of 149
Quarry of 149
Ref. 31
Standard Iron Co.
Blast furnace 153
Ref. 17
Standard Natural Gas Co., Ltd. 38
Standard Oil Company of Canada, Ltd. 38
Standard silver mine.
Tax paid by, 1915 46
Standard White Lime Co.
Operations of, 1915 149
Ref. 28, 31
Staples, W. A. 106
Starr, J. R. L. 114
Stasiuk, Peter 64
Statistics, mineral.
Report by Rogers 1-51
Steel.
Statistics. *See* Iron production.
Steelton, practice 152
Steel Company of Canada.
Blast furnaces 153
Ref. 17
Slag sold by 145

PAGE
Steele, Edwin 26
Steelton, Ont.
Blast furnaces at 152
Steenman, Leonard F. 110
Steindler, D. M. 80, 110
Steindler, E. L. 81, 110
Stellite.
Manufacture of 154
Stephenson tp.
Feldspar 131
Sterling Gas Co., Ltd. 38
Sterritt, David 160
Stevens, Frank G. 120
Stevens, Marshall A. 162
Stevenson, W. E. 105
Stevensville Natural Gas & Fuel Co. 38
Stewart, H. J. 109
Stewart, J. H. M. 143
Stickwood, Charles 26
Stone, R. S. 145
Stone. *See* Quarries.
Stone, building. *See* Building Stone.
Stoness, J. M. 133
Stoness, J. M., & Sons 132
Stout, A. V. 85
Street & O'Brien.
Granite quarry of 144
Streit, C. H. 124
Sturgeon lake.
Gold mining 68
Styles, Geo. 161
Success gold mine. *See* Triumph gold mine.
Sudbury mining division.
Office statistics, 1915 43
Recorder's report, 1915 43
Sudbury nickel area.
Accidents, number of 58
Mining lands sold and leased 45
Operating mines of 69
Sudbury Brick Co., Limited 26
Sudbury Leasing and Development Co. 14, 42
Sully, W. J. 161
Sulpharsenides.
Cobalt area, deposition 243
Treatment of 201
Sulphur.
Cobalt area, in ores 204, 205, 206, 218, 234, 238, 243
determination 202
Sun Brick Co. 26
Superior Brick Co. 26
Sundy Gas Well Co. 38
Sulphide, Ont.
Sulphuric acid works 192
Sulphide Chemical Co. 197
Sulphuric acid.
Brockville 195
Pyrite suitable for 34
Sulphide, Ont. 196
Superior National Park 191
Superior Sand & Gravel Co., Ltd. 29
Superior Sand & Towing Co., Ltd..29, 30
Sutherland, T. F.
Report by, on accidents 52
Report as Inspector of Mines 66
PAGE
Ref. 193
Swastika.
Molybdenite 21
Telluride, origin 262
Water power for 253
Swastika gold mine 82, 259
Swastika Gold Mines, Limited 42
Sydenham, Frontenac co.
Mica mining near 35, 132
Sydenham Mica & Phosphate Mining Co., Ltd. 42
Syenite.
Boston Creek gold area 250, 253
Otto tp. 250
Symmes, John 149
Symplesite.
In Cobalt area 200
analysis 237
chemical properties 236
percentage in ores 239

Taggart mica mine.
Operations at, 1915 133
Ref. 35
Talc.
Industry 41
At Madoc 1
Mining of, 1915 129
Producers, list of 41
Production 3, 4
Tallen Mining Co., Ltd.
Mining operations of 126
Officers of 126
Talon Chute.
Molybdenite 21
Tamarac.
Hunter island iron region 191
Tashota.
Gold discovered near 8
Tashota gold field 44
Taxation. *See* Mining Tax Act.
Taylor, E. O. 126
Taylor, Frank 161
Taylor, George 90, 111
Taylor, Gordon 123
Taylor, Harry L. 99
Taylor, J. Frater 152
Taylor & Hall 26
Taylor Bros. 26
Taylor silver claim.
Operations at, 1915 126
Teck tp.
Gold mining 82, 83
Kirkland Lake Gold Mines holdings in 82
Teck-Hughes gold mine.
Cyanide mill on 83
Ref. 8
Telephone City Oil & Gas Co., Limited 38
Tellurides.
Maisonville tp. 85
Telluride (bismuth).
Pacaud tp. 256
Tellurides of gold.
Morrissette tp. 261
Tellurium.
Boston Creek gold area 252, 256

PAGE
Temiskaming and Hudson Bay silver mine.
Erythrite and scorodite 240
Temiskaming Mining Co., Ltd.
Dividends of 6
Mining operations 122
Officers 122
Ref. 11
Temiskaming silver mine.
Fatal accident at 64
Deep exploration 11
Production 10, 11
Tax paid by, 1915 46
Terra cotta. *See* Brick.
Terra Cotta Pressed Brick Co., Ltd... 26
Terrace Cove, Lake Superior.
Molybdenite 21
Terrill, Albert 85
Tetrahedrite.
Cobalt area 209
Tett mica mine.
Operations at, 1915 133
Thames Quarry Co.
Operations of, 1915 150
Ref. 31
This Man lake.
Conglomerate 167
Iron ranges 163, 165, 167, 177
claims 169-173
Water power 190
Thomas, Fred. W. 103
Thomas, George 81
Thomas, G. G. 106
Thomas, William 161
Thompson, Albert 161
Thompson, G. L. 113
Thompson, James 106
Thompson, Philip and Urquhart 142
Thompson, Wm. 148
Thomson, Ellis 163
Thorne, Stuart M. 123
Thornton, John 26
Thorold.
Refinery near 153
Thorold Gas Company 38
Thunder Bay dist.
Iron deposits 184
Mining lands sold and leased 45
Thunder Bay Contracting Co. 30
Tiffin, Arthur 162
Tilbury oil field.
Gas line inspection 35
Production, 1915 40
Tilbury Town Gas Co. 38
Tile, drain.
Manufacturers, list of 23
Production 3, 6
Timagami forest reserve.
Mines in 103
Timiskamian.
Lebel tp. 261
Timiskaming dist.
Gold. *See also* Boston Creek gold area, Goodfish Lake gold area.
Mining lands sold and leased 45
Timiskaming (including Coleman) mining div.
PAGE
Office statistics, 1915 43
Timiskaming series.
Teck tp. 261
Timiskaming & Northern Ontario Ry.
Pacaud tp. Building stone 253
Pyrite at mile 153 252
Porquis Junc., nickel mining near .. 103
Timiskaming and Northern Ontario Railway Commission.
Royalties paid to 45
Timmins, Noah A. 94
Tisdale tp.
Gold mining 96, 103
Tisdale Gold Mining Co. 85
Tomenson, Joseph 89
Topography.
Boston Creek gold area 246
Hunter island 165
Toronto.
Building trade, 1909-1914 22
Toronto Brick Co.
Limestone quarry of 144
Ref. 26
Toronto Gas & Oil Company, Ltd. 43
Toronto Lime Co.
Quarries of 150
Ref. 28
Toronto Pressed Brick & Terra Cotta Co. of Milton, Limited 26
Tough, J. H. 84
Tough-Oakes gold mine.
Development of 83
Mill, flow sheet 84
Operation and plant 83
Ref. 5, 7, 8, 244, 259, 261
Tough-Oakes Gold Mines, Ltd.
Dividends of 6
Ref. 9
Townsend, Edward J. 103
Townsend, James 103
Townsite-City silver mine.
Location 11
Townsite Extension silver mine.
Operations at, 1915 114
Trap rock.
Belmont tp. 142
Port Arthur quarry 67
Quarries, list of 30
Road material 29
Travers, Thos. 77
Treasure Hill molybdenite mine.
Operations at, 1915 138
Trees.
Boston Creek gold area 253
Hunter island iron region 191
Tremain, H. E. 105, 122
Trent Valley canal.
Stone crushing plant on 141
Trethewey silver mine.
Location 11
Operations at, 1915 ..... 122, 123
Trethewey Silver-Cobalt Mine, Ltd.
Dividends of 6
Mining operations 121, 122
Officers 123
Ref. 11
Tax paid by, 1915 46

PAGE
Triebner, Frank 162
Trinity co., Cal., U.S.A.
Gold mine, worked by Crown Reserve Mining Co. 110
Triumph gold mine.
Operations at, 1915 103
Triumph Mines, Ltd.
Directors and gold mine of 103
Ref. 43
Trocatto, Gusette 64
Tudhope, J. B. 98, 123, 136
Tummon W. E. 141
Turtle, Samuel 162
Twentieth Century Mining Co., Ltd.
Mining operations of 123

Uglow, Dr. W. L. 131
Union Carbide Co.
Calcium carbide works of 32
Union Natural Gas Co. of Canada, Ltd.
Pumping plant 36
Ref. 38
Union Stock Yards 161
United Fuel & Supply Co. 29
United Gas Companies, Limited 38
United Gas & Fuel Co. of Hamilton, Ltd. 38
University silver mine.
Location 11
Operations at, 1915 112
Rammelsbergite 228
Urquhart, W. J. 137

Vacuum Gas and Oil Company, Ltd... 42
Van der Voort, M. P. 98, 110
Van Hise, C. R. 166, 247
Vanophen, Jean 135
Vansickle, A. W. 38
Van Zant 110
Varley, Walter 162
Vermilion iron range, Minnesota 165
Vermilion nickel mine.
Operations, 1915 73
Production 15
Ref. 69
Vermilion Lake pyrite deposits 192
Vernon, George H. 68
Verona.
Feldspar mining 33
Victoria co.
Limestone 144
Molybdenite mining 18
Victoria feldspar quarry.
Operations at 132
Ref. 33
Victoria nickel mine.
Location 14
Operations and equipment 76
Production, 1915 15
Vinemount.
Limestone quarrying near 151
Vipond gold mine. *See also* Porcupine—Vipond gold mine.
Statistics, 1915 7
Voakes, Edward R. 26
Vollhardt, G. 201, 219, 241

PAGE
Waddell, J. C.
Report by, on oil production, 1915... 40
Wabigoon.
Dominion Reduction Co.'s operations near 66
Wager, Wm. 18
Wagstaff, A. H. 26
Waide Bros. 26
Waines & Root Gas Co., Limited 38
Waite, J. E. 26
Waldman silver mine.
Royalties paid by 45
Walker, Hiram 161
Walker, Jay 28
Walker, R. T. 112
Walker Bros. 31
Wallace & Son, R. 26
Wallaceburg Brick Co. 26
Walper, Louis 162
Walpole tp.
Limestone 147
Walsh, W. J. 161
Ward, Henry H. 102
Wardle, John 26
Warren, Wm. 19
Warren molybdenite claim.
Operations at, 1915 138
Water power.
Blanche river 253
Boston Creek gold area 253
Hunter Island area 188
Kowkash gold area 271
Legislation respecting 5
Porcupine area, for gold mines 7
Water supply.
Cobalt camp 11, 117
Watson, C. E. 117
Watson, John 161, 162
Watson, J. P. 106
Watson, R. B. 112, 119
Watson Brick Co. 26
Watts, Ernest E. 156
Electrolytic process 156
Watts silver mine.
Tax paid by, 1915 46
Watts, Wm. 162
Wawaitin falls, Mattagami river 7
Weatherbee, D'Arcy 117
Weaver, Thomas 161
Webb, William 161
Webber, John, Sr. 31
Weber, Arthur 162
Webster, James S. 31
Webster & Stewart 133
Wedrick, M. 38
Weed, Floyd 82
Weese, William 161
Wehlann & Son 26
Welch safety clutch.
Description 88
Welch safety device 76
Welcome, Municipality of Hope tp.
Gravel 160
Weichel, W. G. 106
Welland.
Calcium carbide works 32

PAGE
Metal refinery 156
Zinc refining works 155
Welland co.
Gas field, report, 1915 36
Limestone 145
Welland County Lime Works Co., Ltd. 31, 38
Welland-Haldimand gas field.
Production, 1915 39
Wellandport Natural Gas Co. 38
Wellington, Stephen 130, 197
Wellington pyrite claim.
See Canadian Sulphur Ore Co.
Wellman, Albert 28
Wells, J. L. 139
Wells, J. P. 156
Wells, R. G. 153
Welsh, Joseph P. 123
Wentworth co.
Natural gas 39
Wentworth Quarry Co.
Operations of, 1915 151
Ref. 31
Weppler, Henry 26
West Dome Consolidated Mines, Ltd.. 43
West Flamborough tp. *See* Flamborough tp.
Westlake, E. H. 111
Western Canada Flour Mills Co., Limited 41
Western Salt Company, Limited 41
Wettlaufer-Lorrain Silver Mines, Ltd.
Dividends of 6
Ref. 111
Tax paid by, 1915 46
Whitbeck, Ernest C. 117
Whitby Brick & Clay Products Company, Ltd. 43
White, Wm. M. 162
White Marble Co. of Canada, Ltd.
Operations of, 1915 140
Ref. 30
White Reserve Mining Co., Ltd.
Operations at silver mine, 1915 127
Whitebread, Thos. 83
Whitefish lake.
Graphite mining at 33, 138
Iron deposits 185
analysis 187
Whitehead, H. 72
Whiting, Robt. 162
Whitlock, Peter 162
Whitson tp.
Silver mining 126
Whittaker, H. M. 161
Wiarton.
Limestone quarrying 146
Wickett, S. R. 123
Wilberforce.
Molybdenite mining near 136, 138
Wilcox Lake Brick Co. 26
Willett tp.
Silver mining 123
William Markus, Ltd. 31
Williams, C. E. 151
Williamson, R. G. 106
PAGE
Williamsburg tp.
Limestone 142
Willmott & Co.
Quartz quarry 80
Ref. 30
Willoughby, J. A. 161
Wilson, A. W. G. 197
Wilson, C. J. 152
Wilson, E. H. 49
Wilson, G. S. 31
Wilson, James.
Molybdenite on farm of 19, 138
Wilson, J. S. 85, 89
Wilson, M. E. 246
Wilson, Thomas M. 59
Wilson, Matawatchan tp.
Molybdenite near 138
Winchell, A. 187
Winchell, H. V. 184
Windle, John 20
Windsor, Essex & Lake Shore R'y. ... 162
Windsor Gas Co., Ltd. 38
Windsor Sand & Gravel Co., Ltd.
Gravel washing plant 157
Officers of 158
Ref. 29, 162
Winter, James 161
Winters, Howard 161
Witbeck, H. M. 90
Wood, John 162
Wood.
Fuel in brick industry 22, 23
Woodruff, Welland D. 109
Woods, Cory 161
Woods, W. H. 26
Woodstock Gas Light Co., Limited... 38
Woodward, E. L. 108
Wookey, S. A. 103
Wooley, John N. 162
Woollatt, Wm. 158
Workmen's Compensation Act 5
Worth, S. Harry 106, 114, 122
Worthington nickel mine.
Accidents 58, 64
Molybdenite 21
Operations and plant 76
Production, 1915 15
Wright, S. B. 155
Wright, Spencer D. 120
Wright, Thomas 101
Wright & Sons, Geo. 26

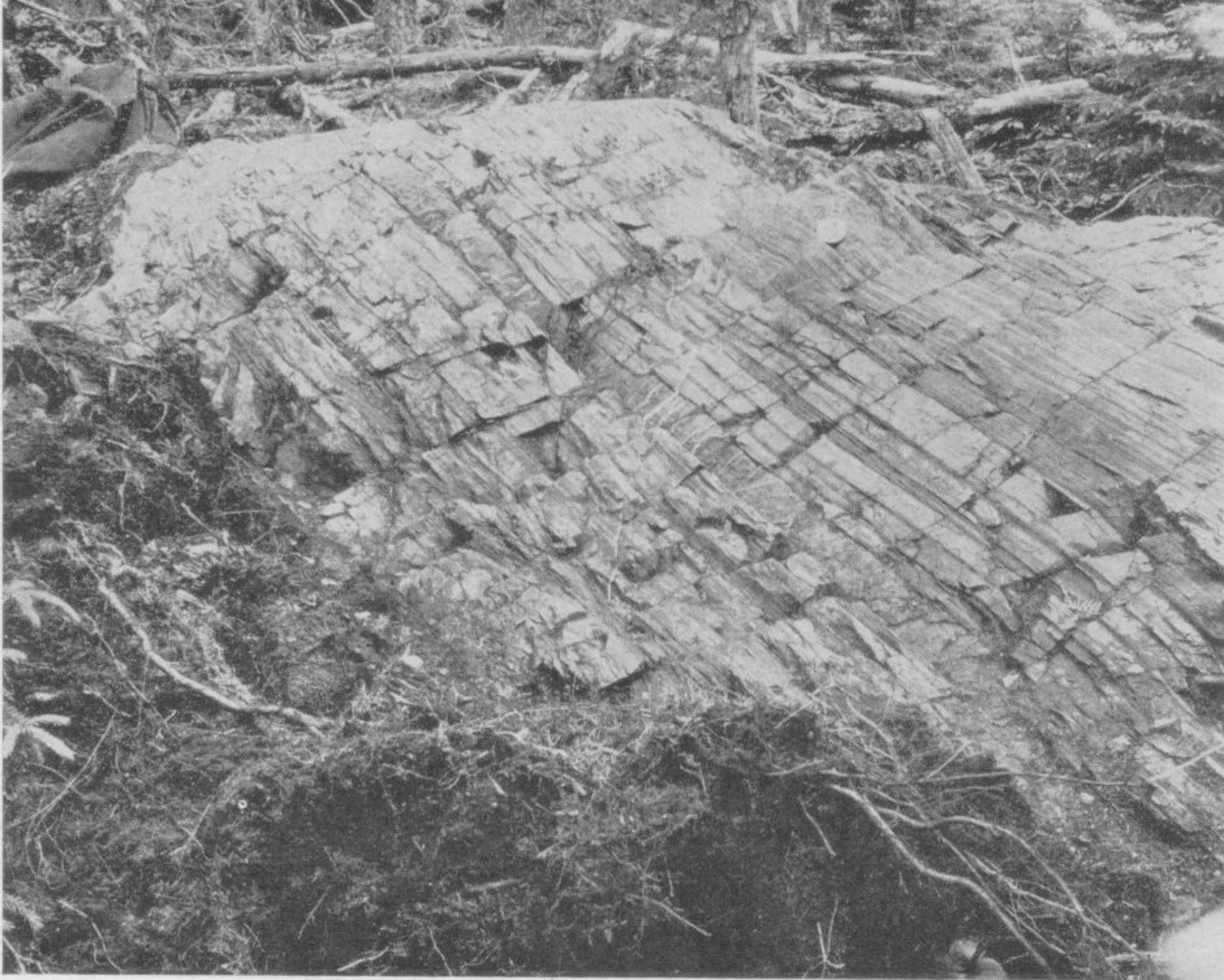
X 24-25-26, iron claims, Hunter island.
Iron ore 169, 171
analysis 173
X 928, iron claim, Hunter island..169, 170
Iron ore 169
analysis 170
photo 170
X 942-3-4, iron claims, Hunter island.
Ore 171
Photo 172
X 944, iron claims, Hunter island.
Ore 169, 171, 172
analysis 173
Photo 172

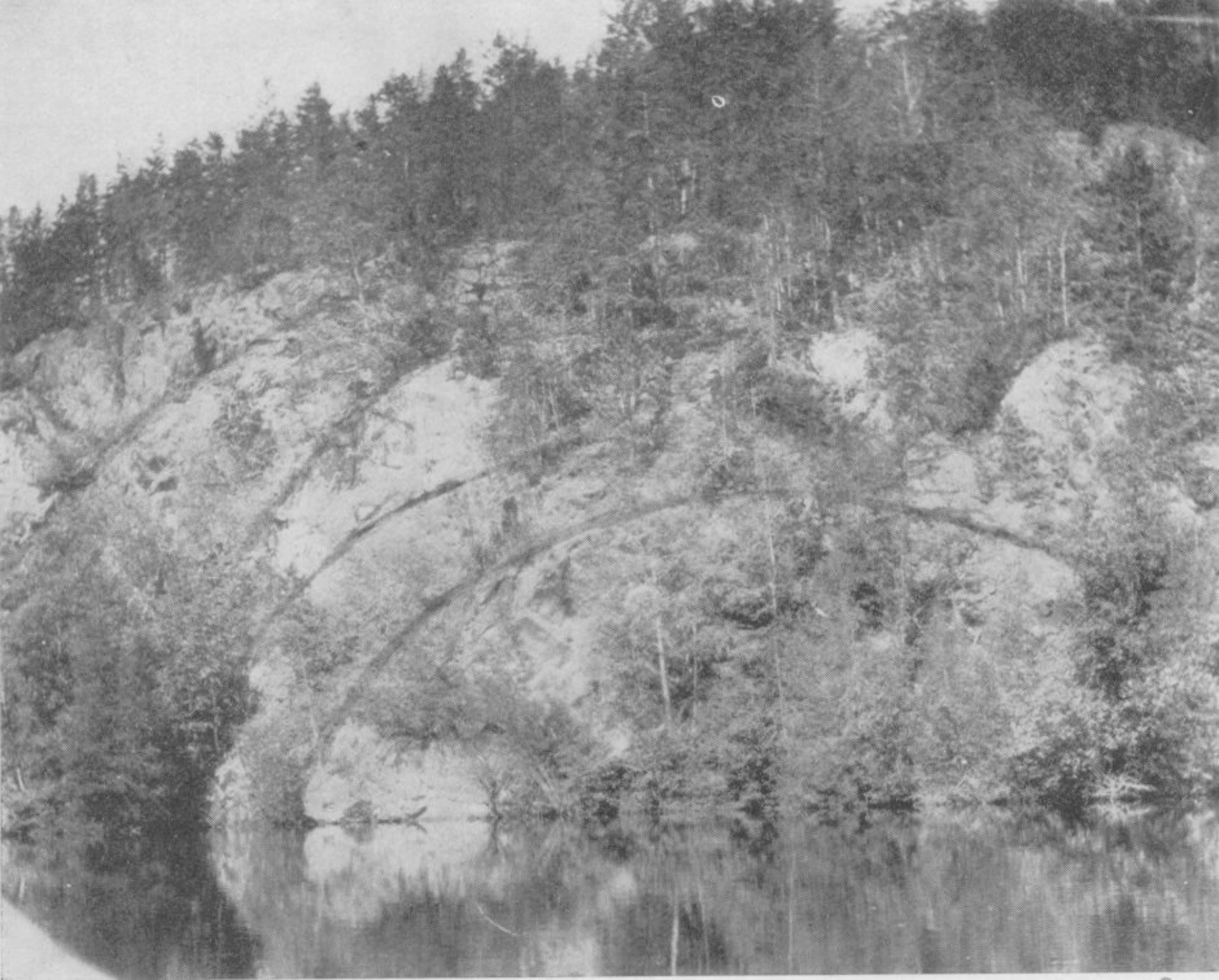
PAGE
X 946, iron claim, Hunter island.
Iron ore 174
X 948, iron claim, Hunter island.
Iron ore, analysis 175
X 968, iron claim, Hunter island.
Iron ores, analyses 171
X 990-1-2-3, iron claims, Hunter island 174

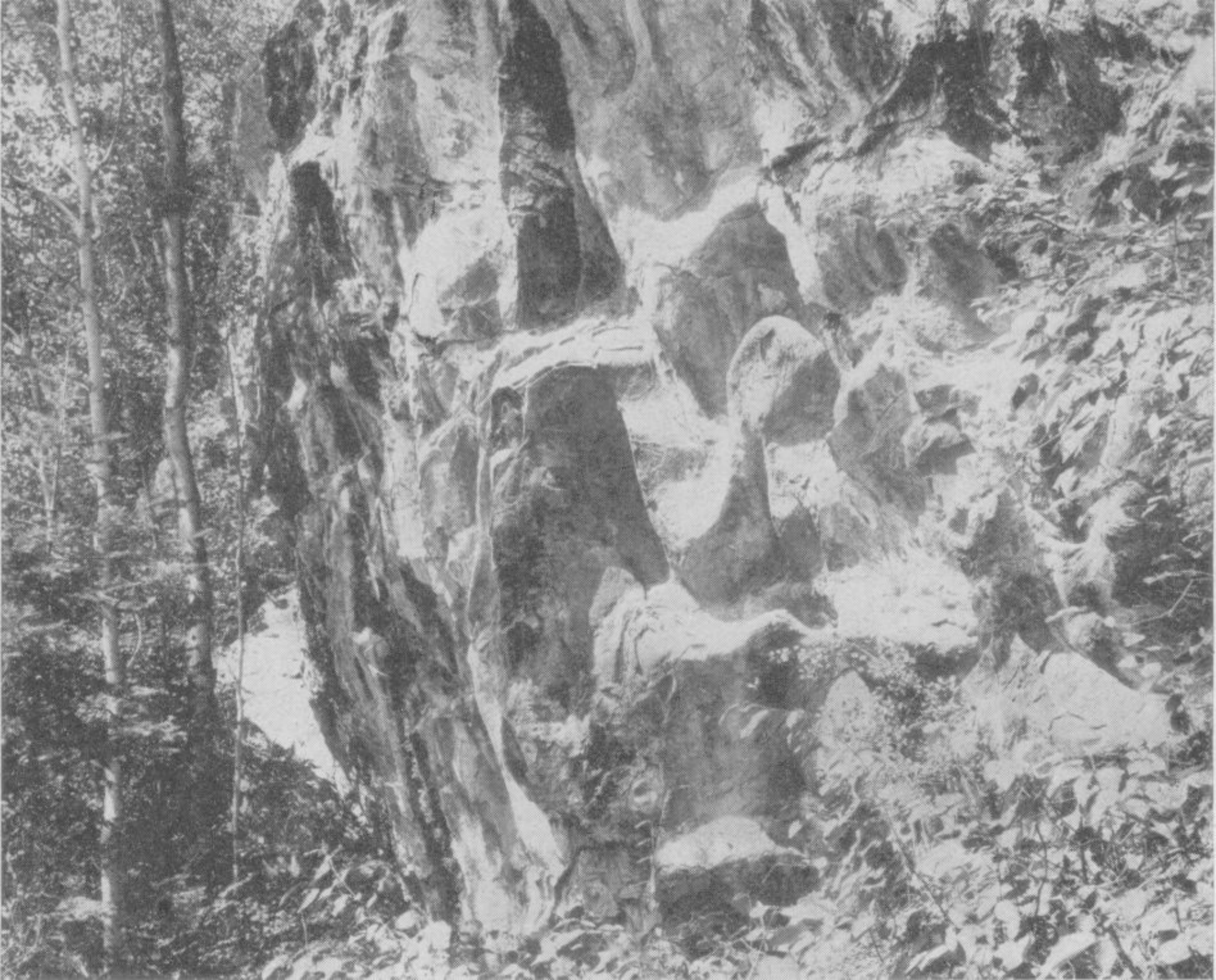
York branch, Madawaska river.
Corundum near 140
York Sand & Gravel Co., Ltd. 29, 161
York Sandstone Brick Co., Ltd. 26
Yaeck, Louis 26
Yapp, Fred. 157
Yates Gravel Pit 161

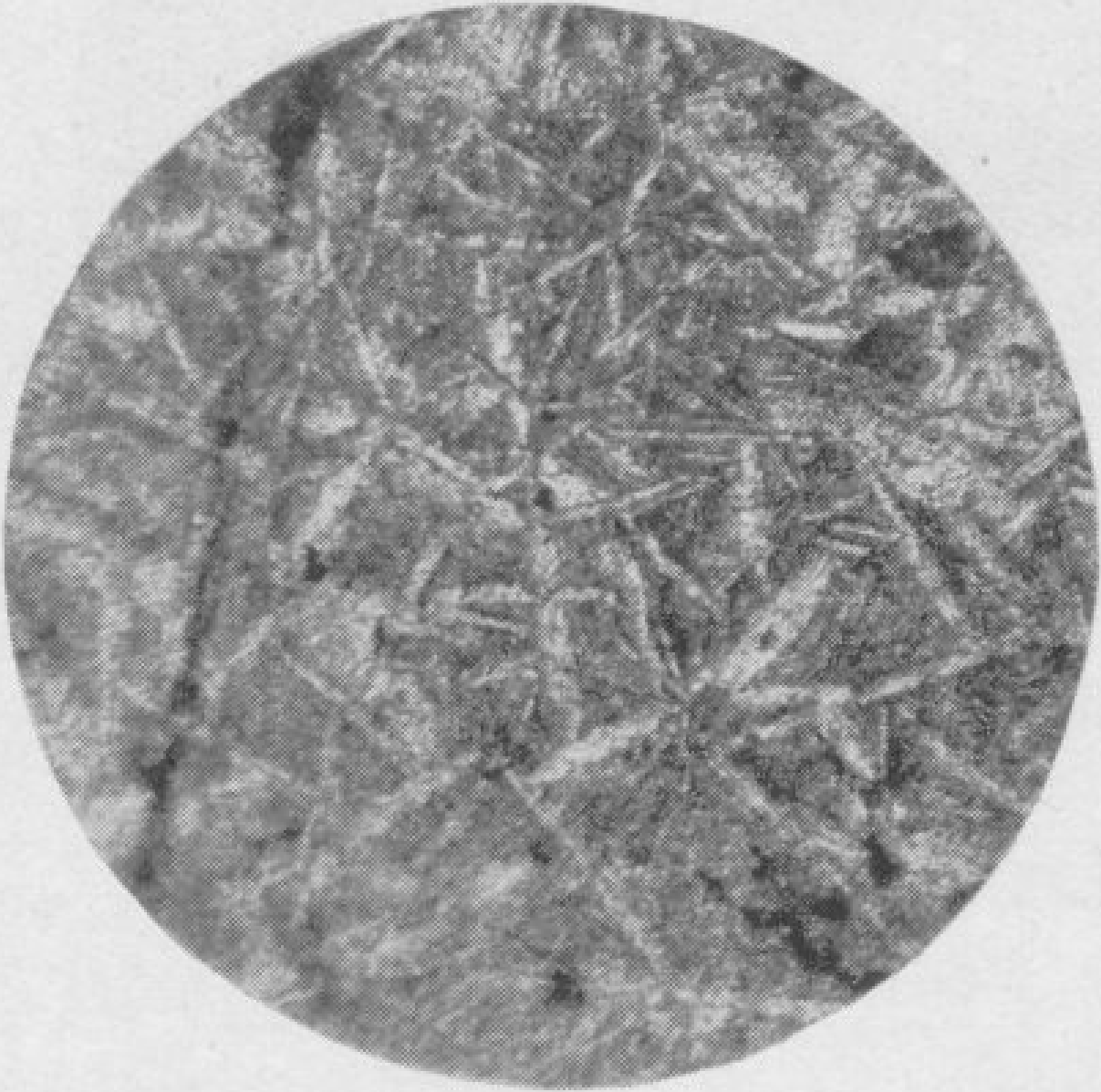
PAGE
Yellow Jacket Gold Mine, Limited ... 43
Young, A. J. 119
Young David 161
Young, F. J. 102
Young, Horace 135
Young, J. H. 103

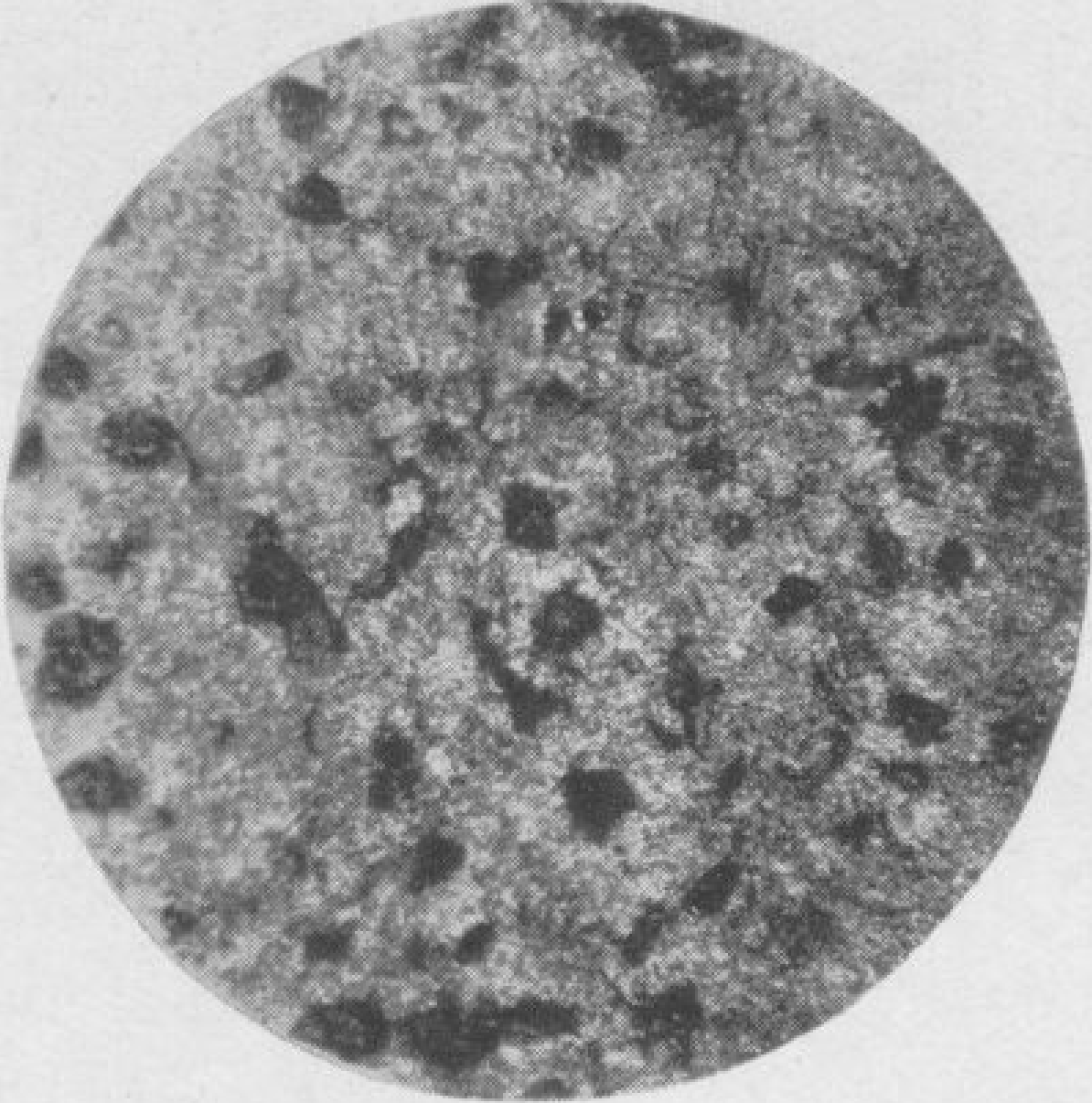
Zakula, George 64
Ziebarth, Edward.
Molybdenite on farm of 20
Zinc.
Production to end 1915 5
Welland, refining works 155
Zoller, F. W. 122

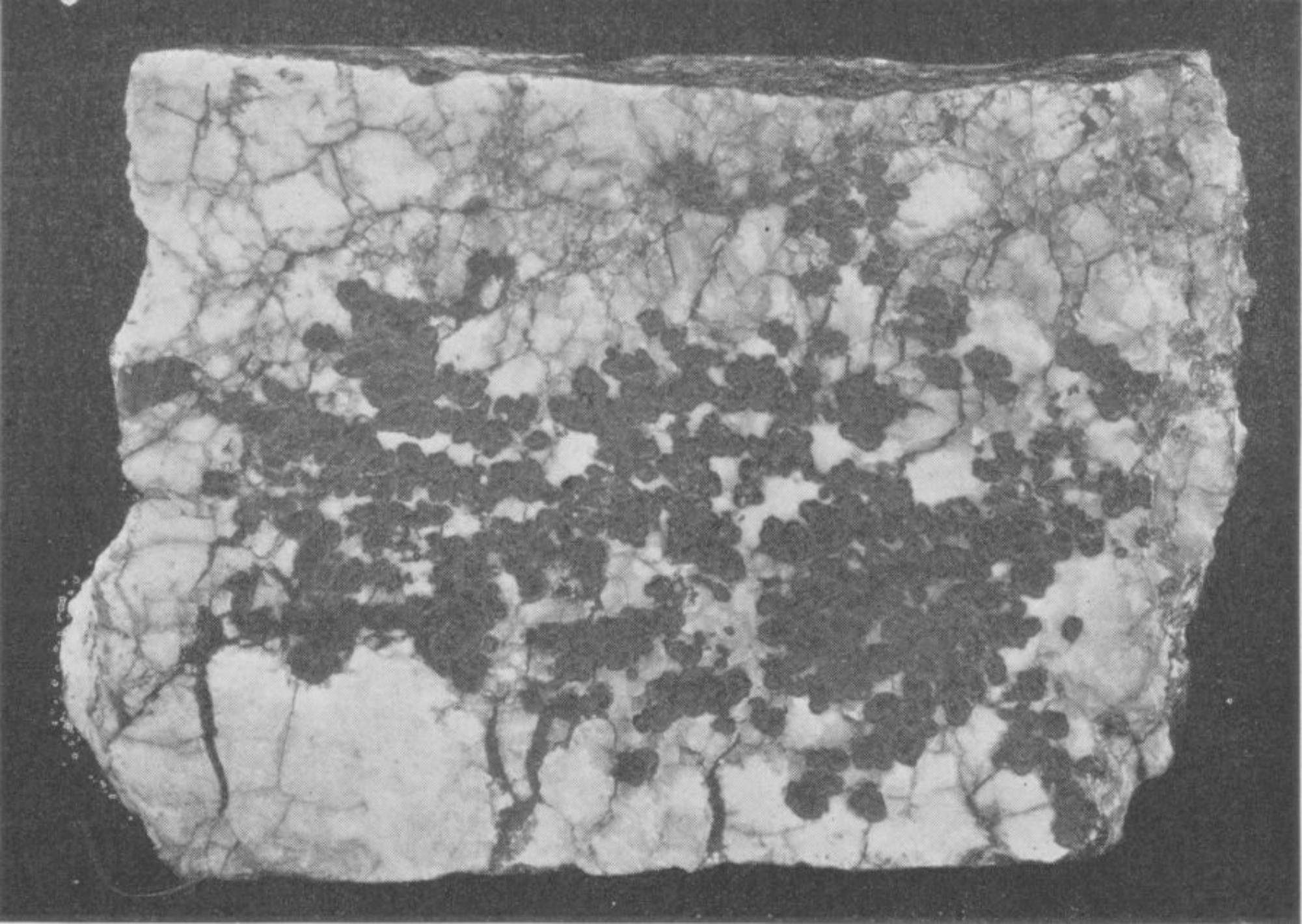


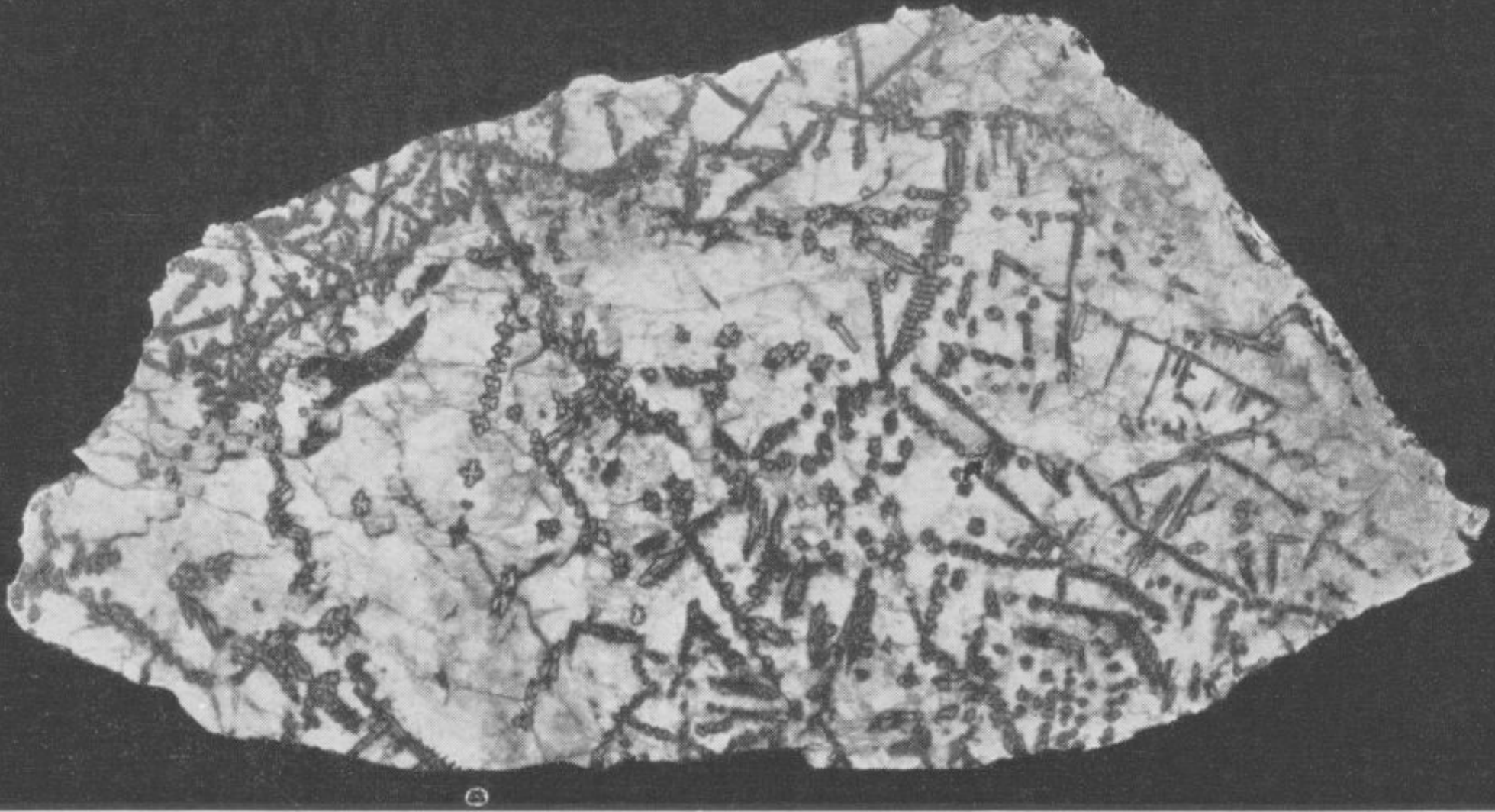












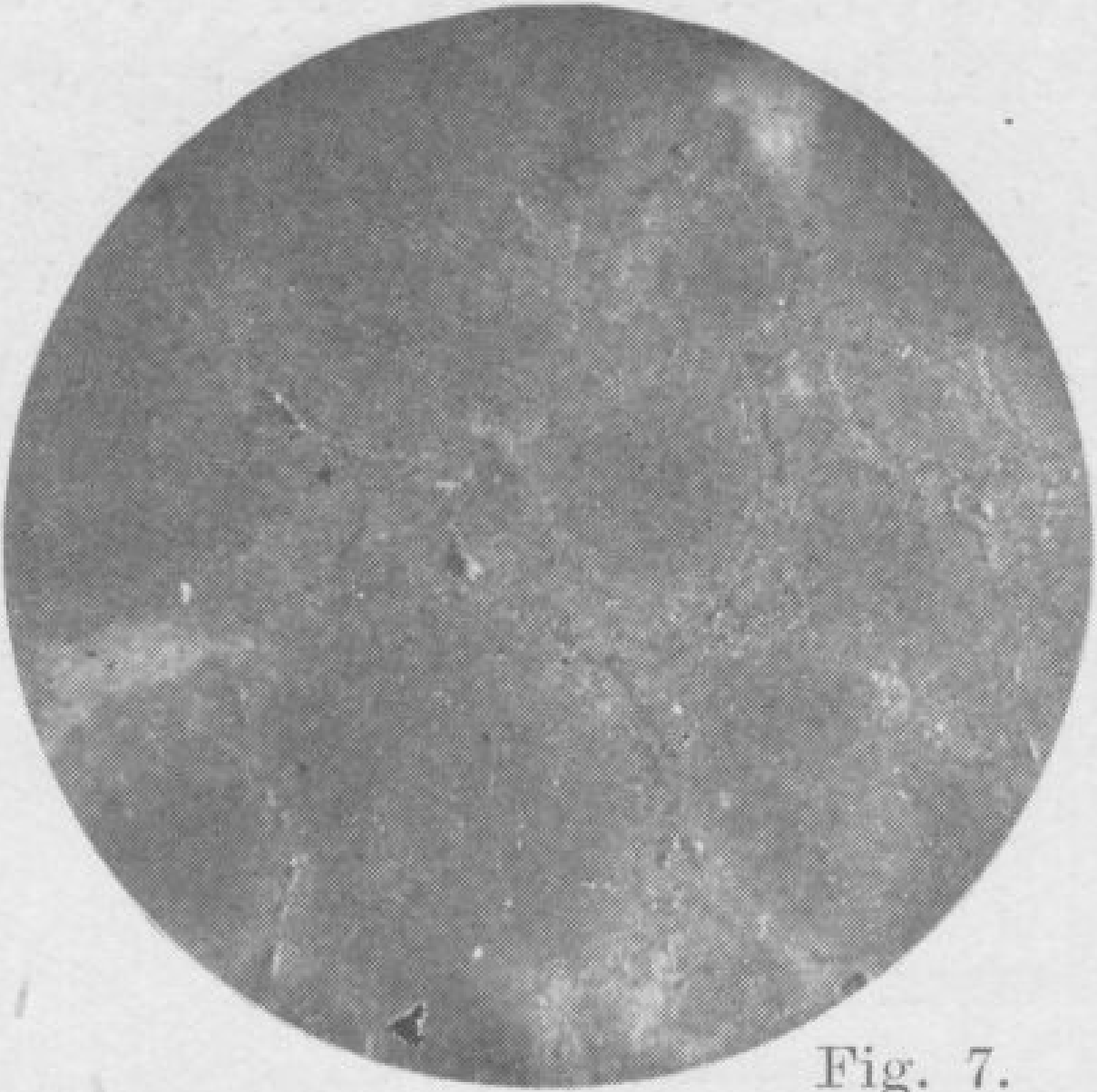
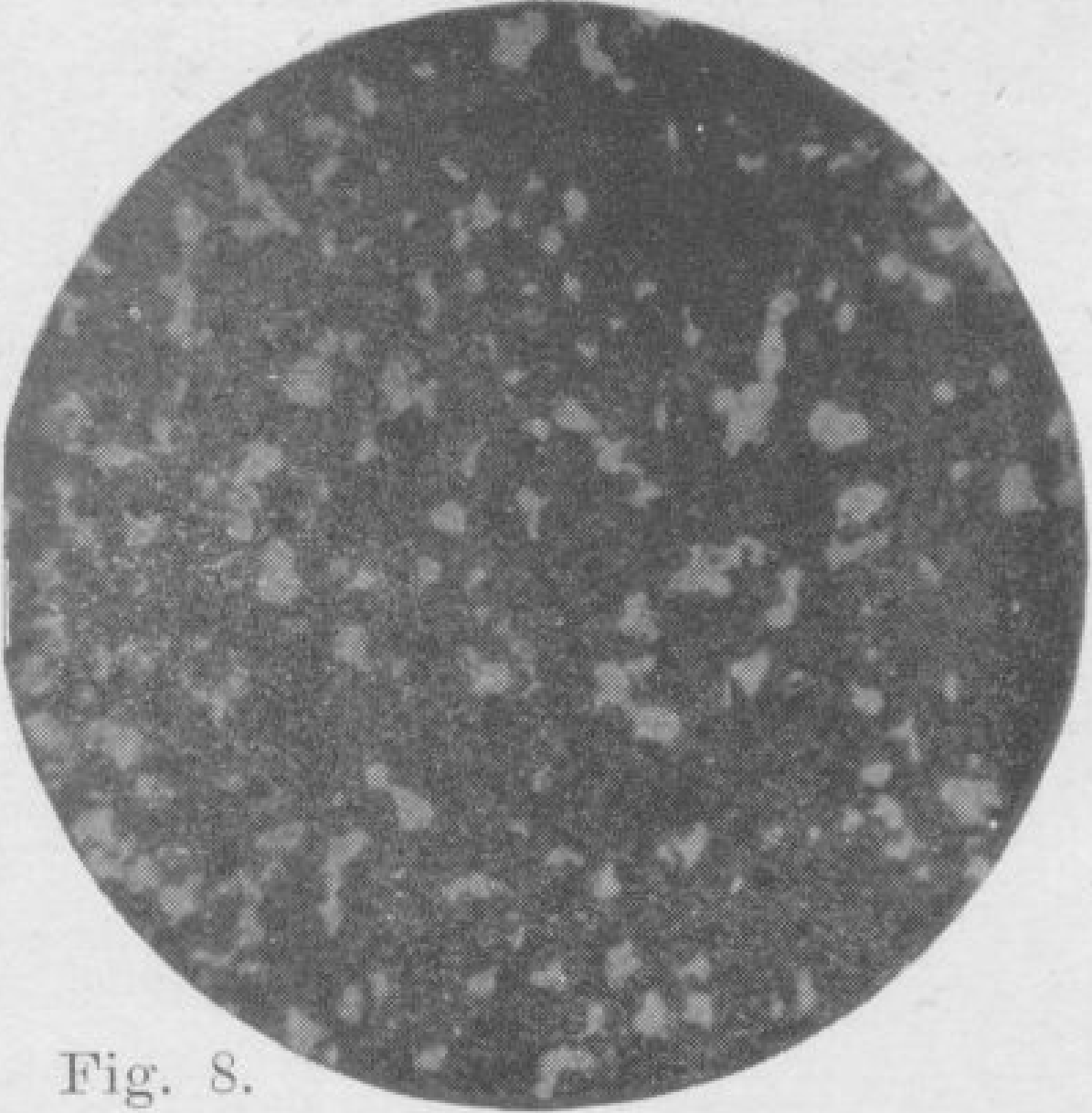


Fig. 7.



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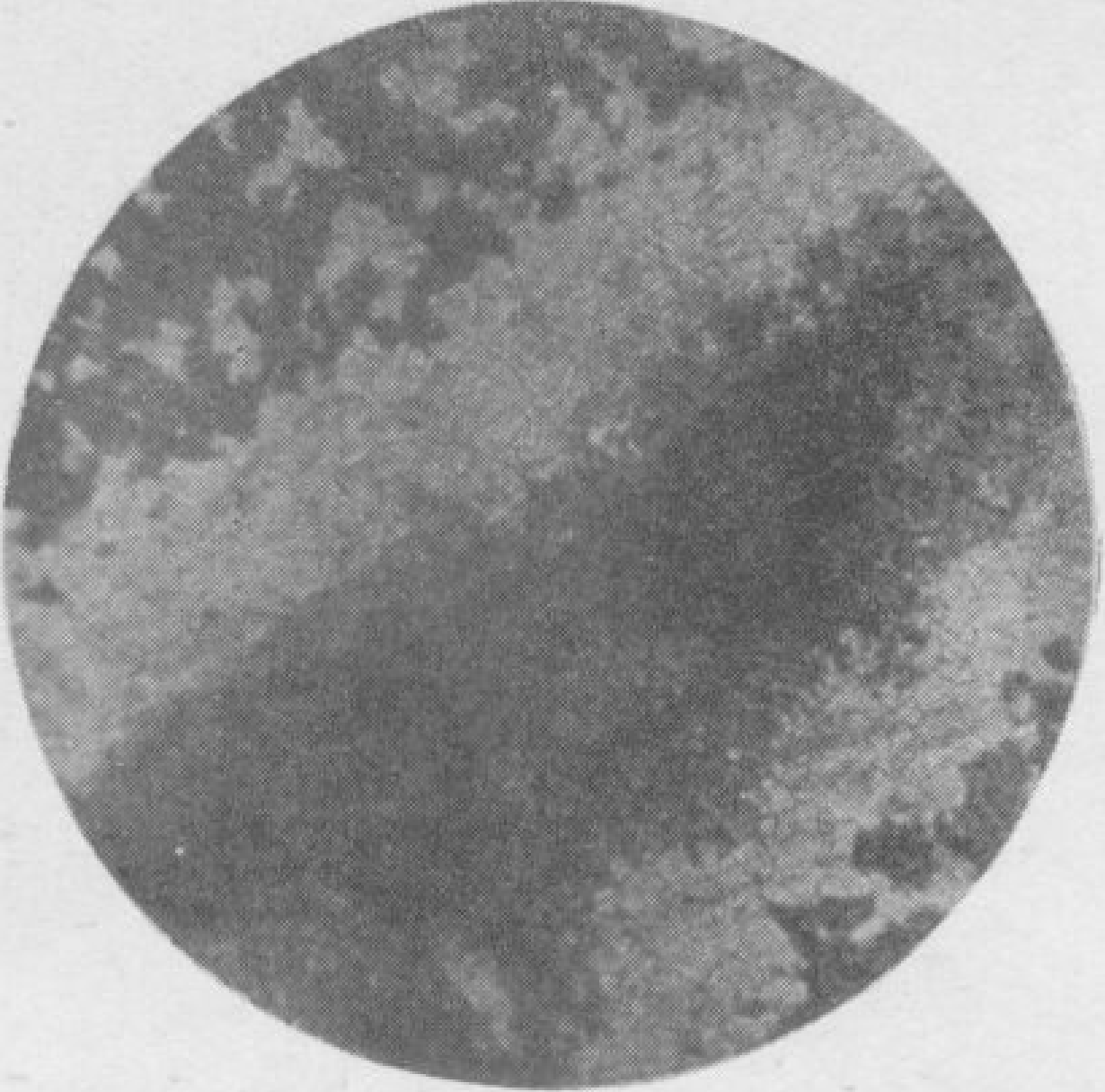

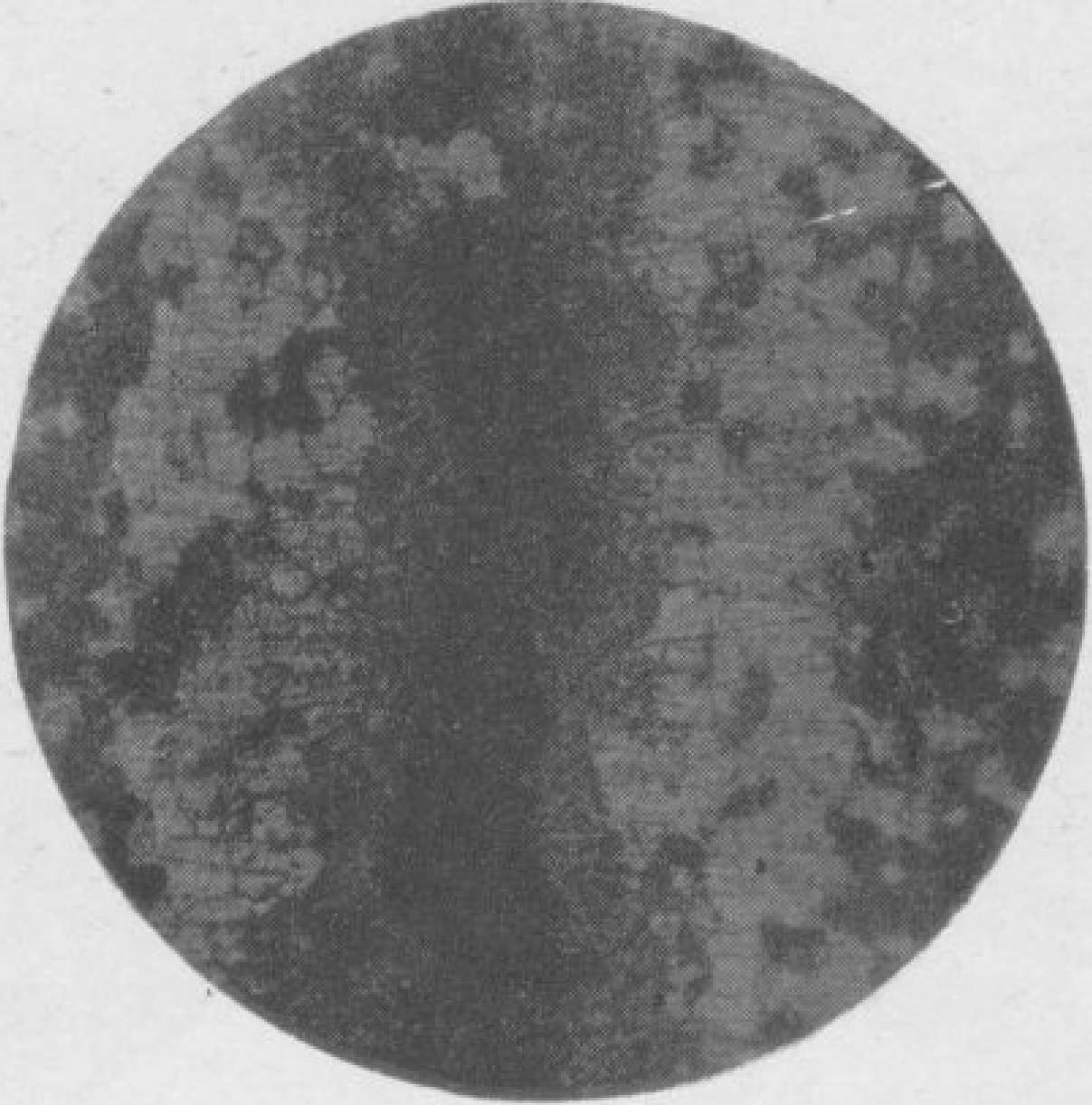

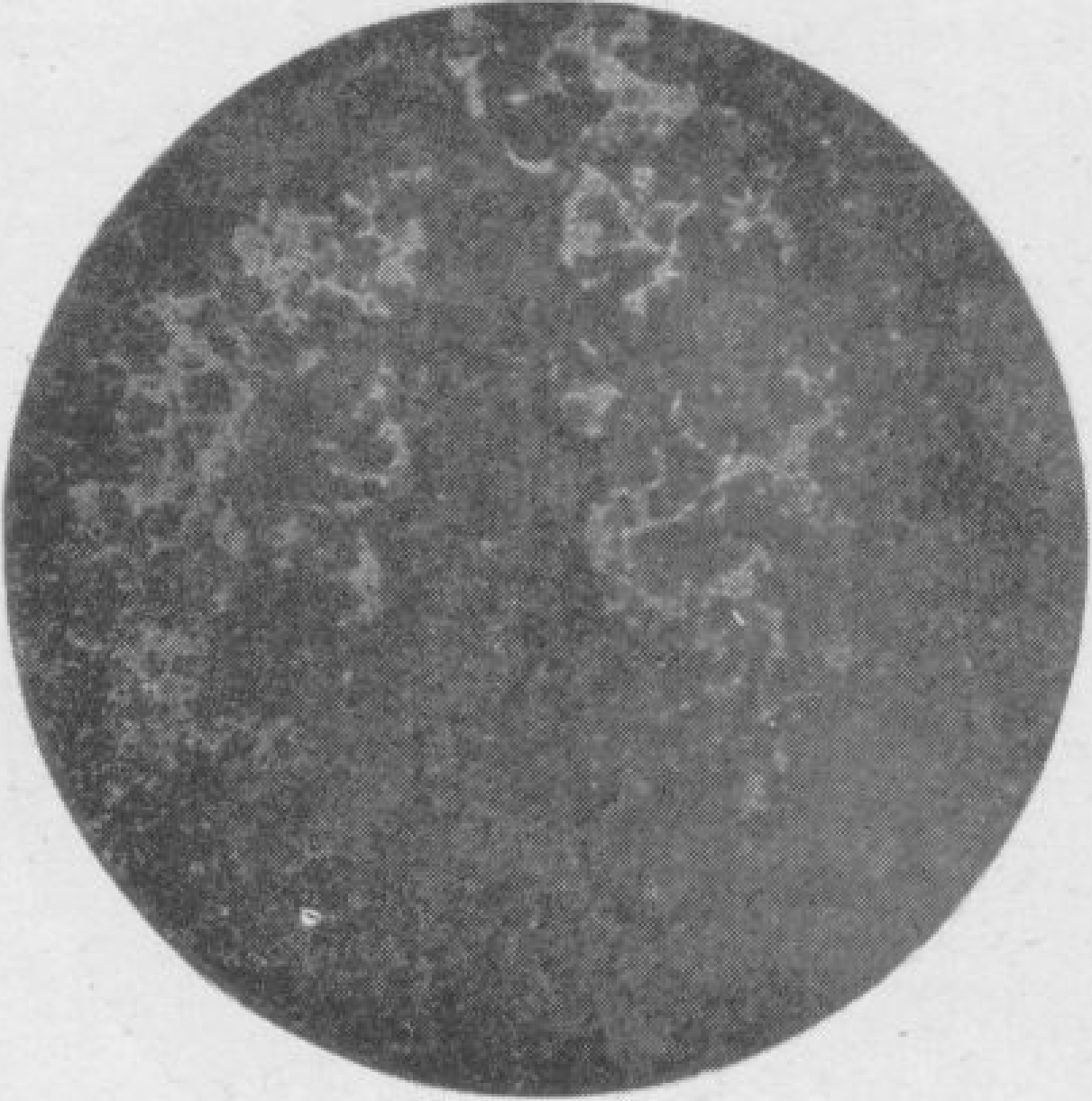

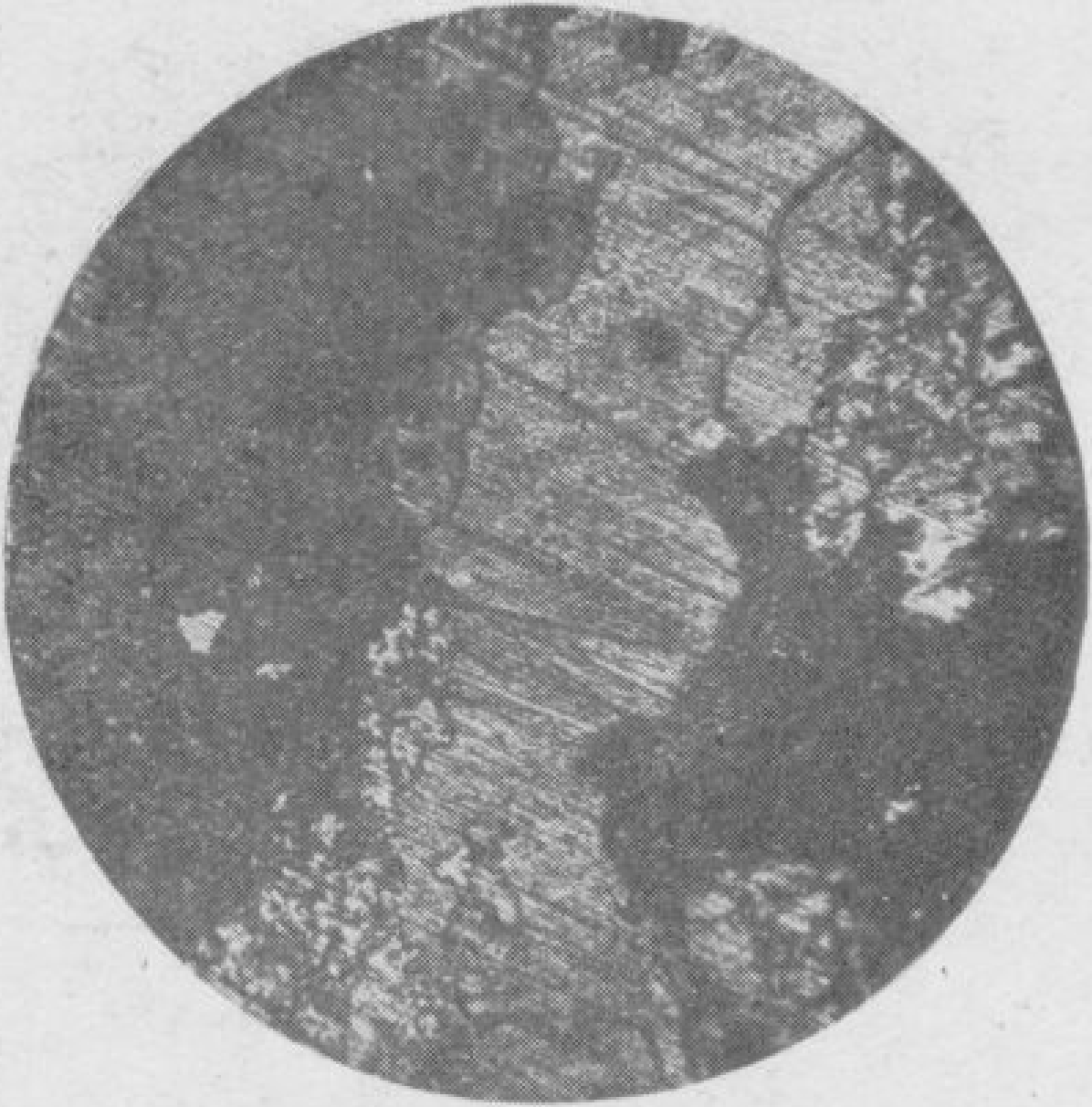

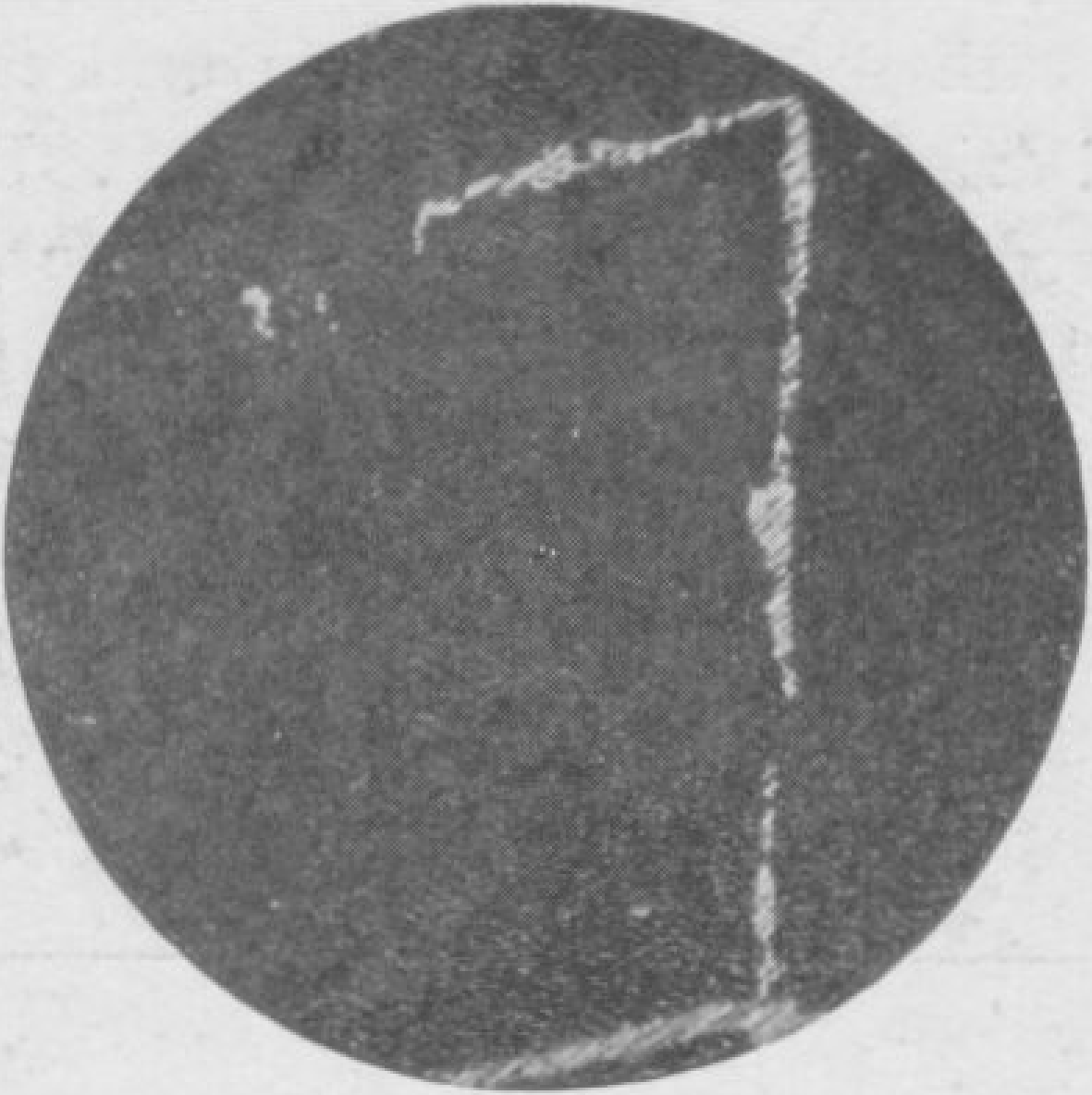

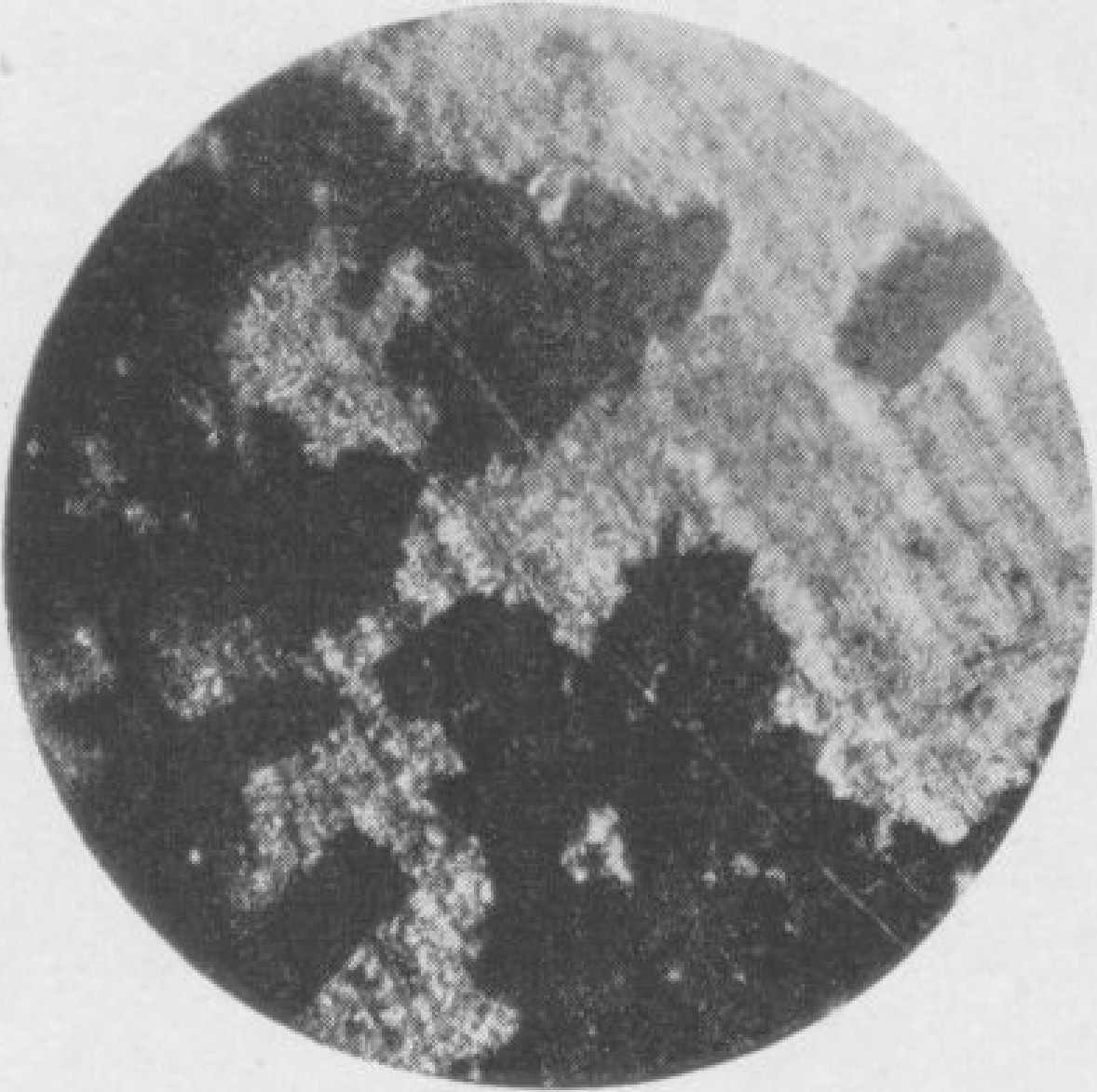

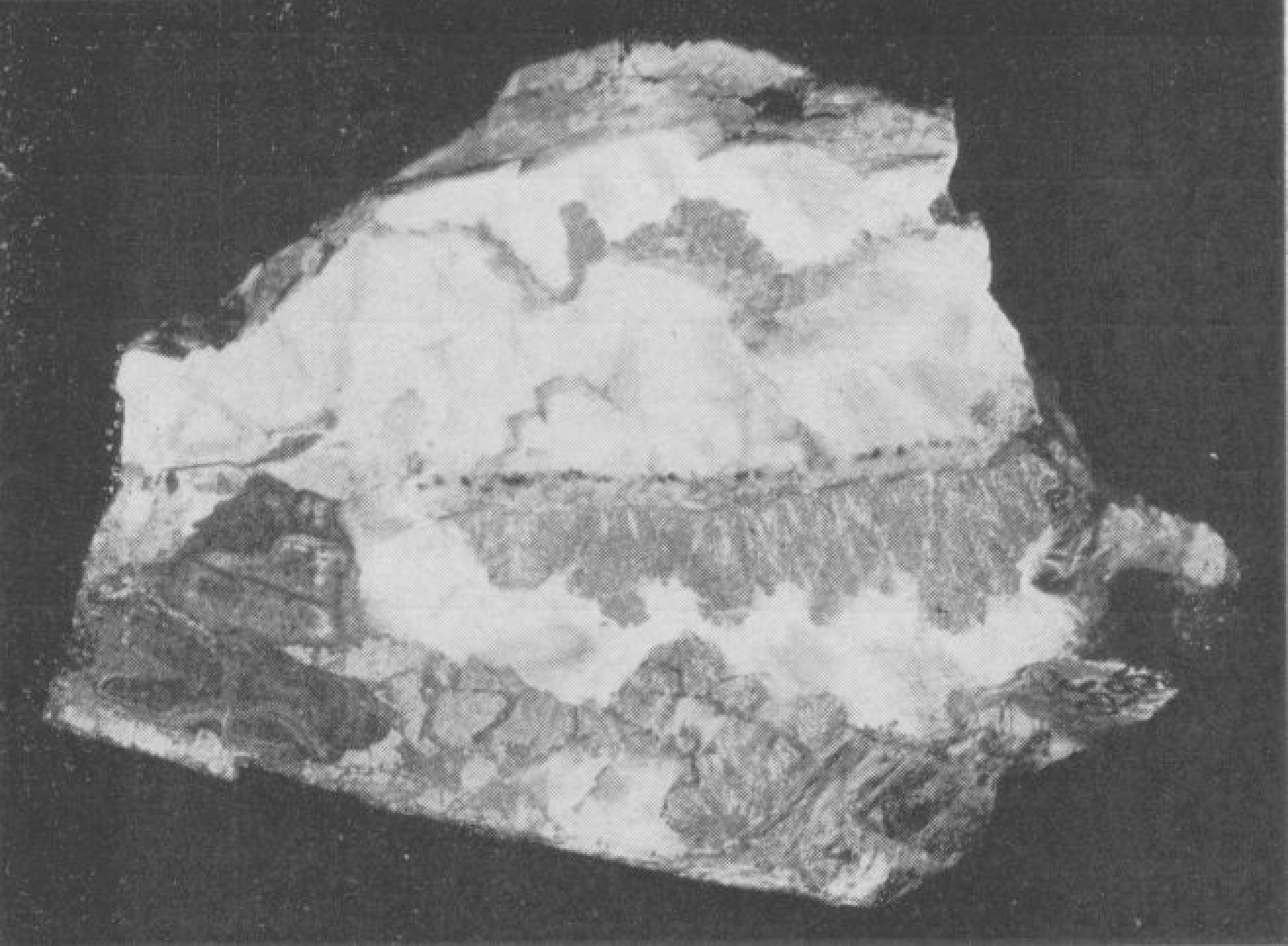

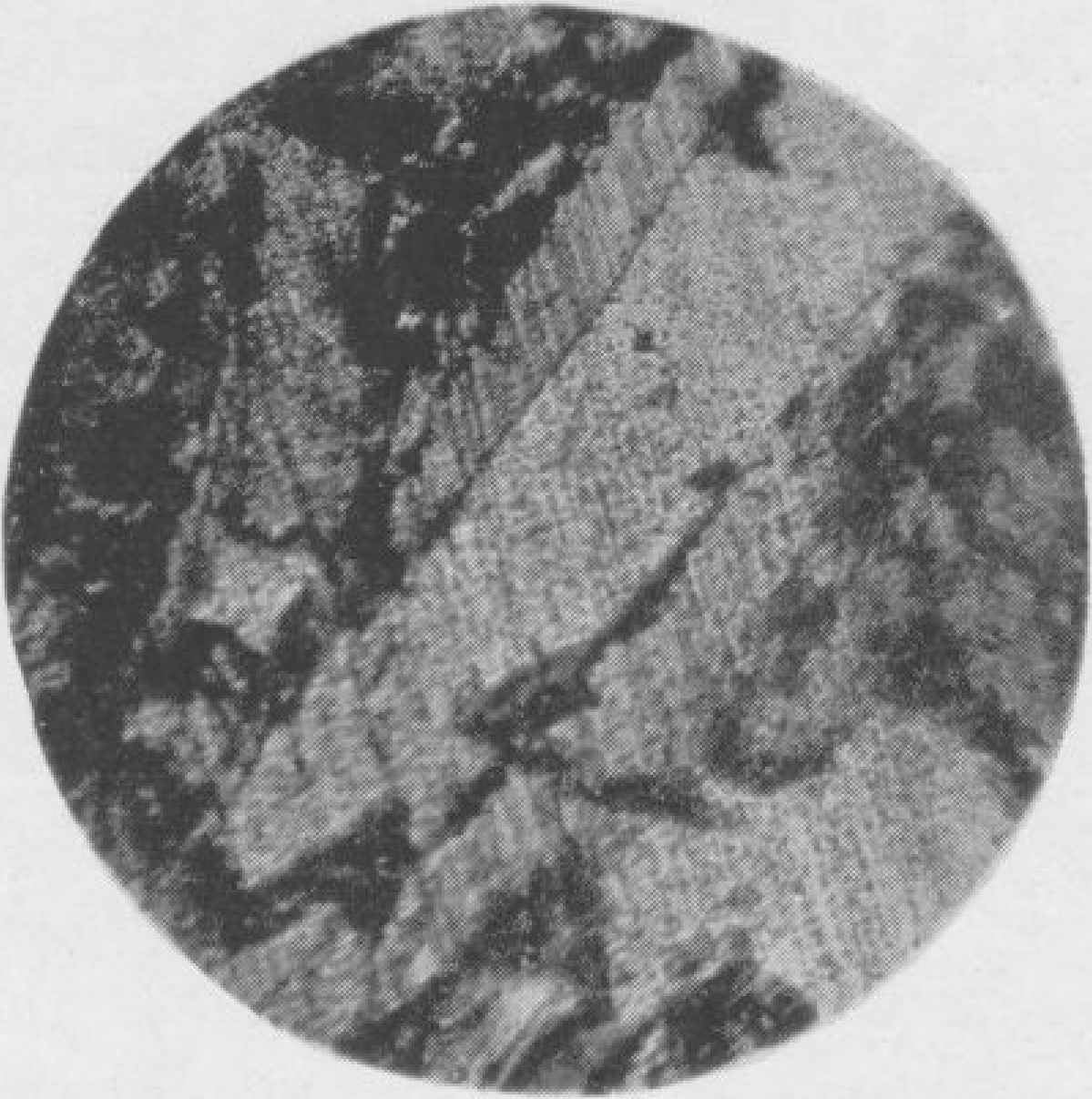

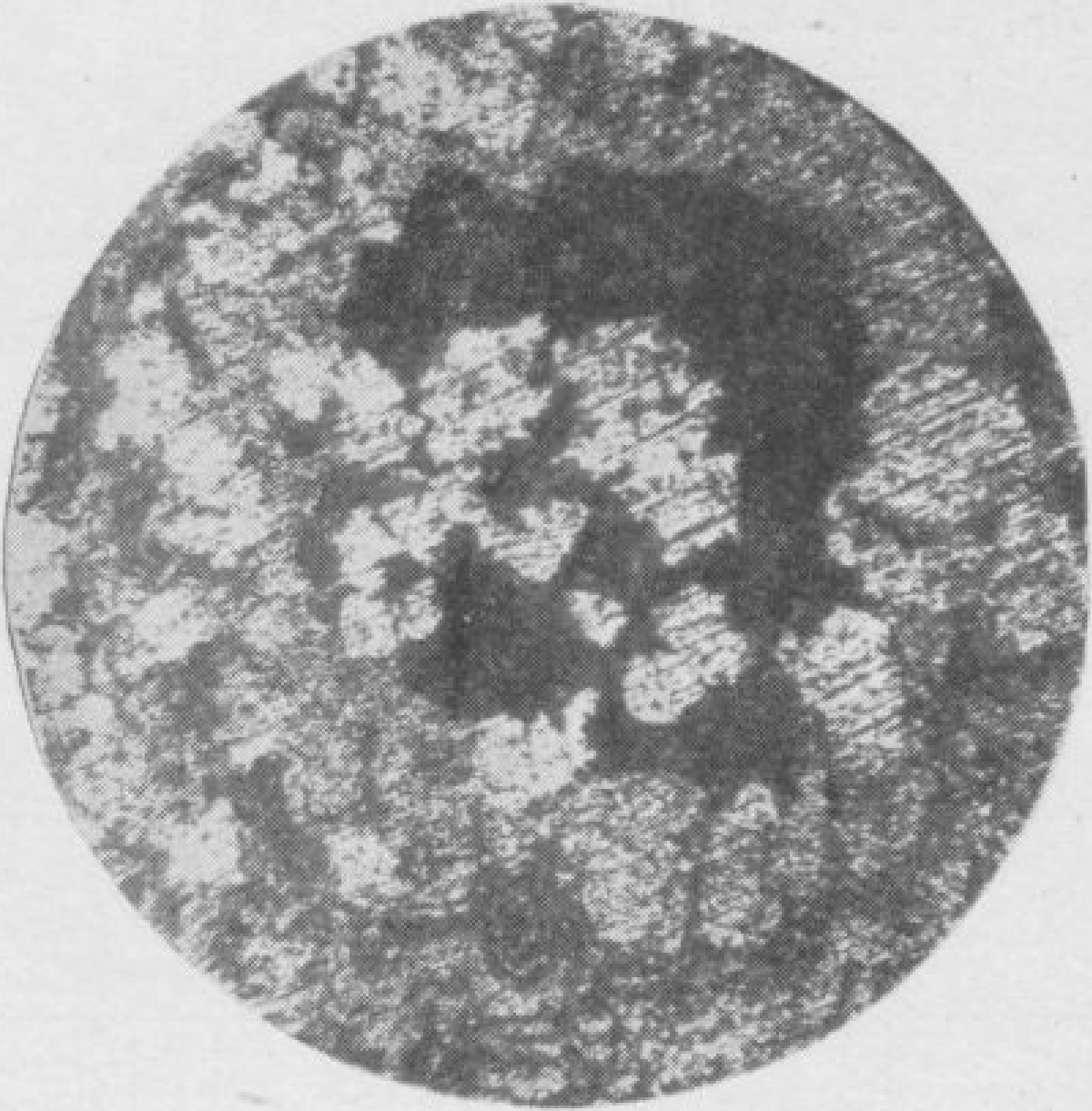

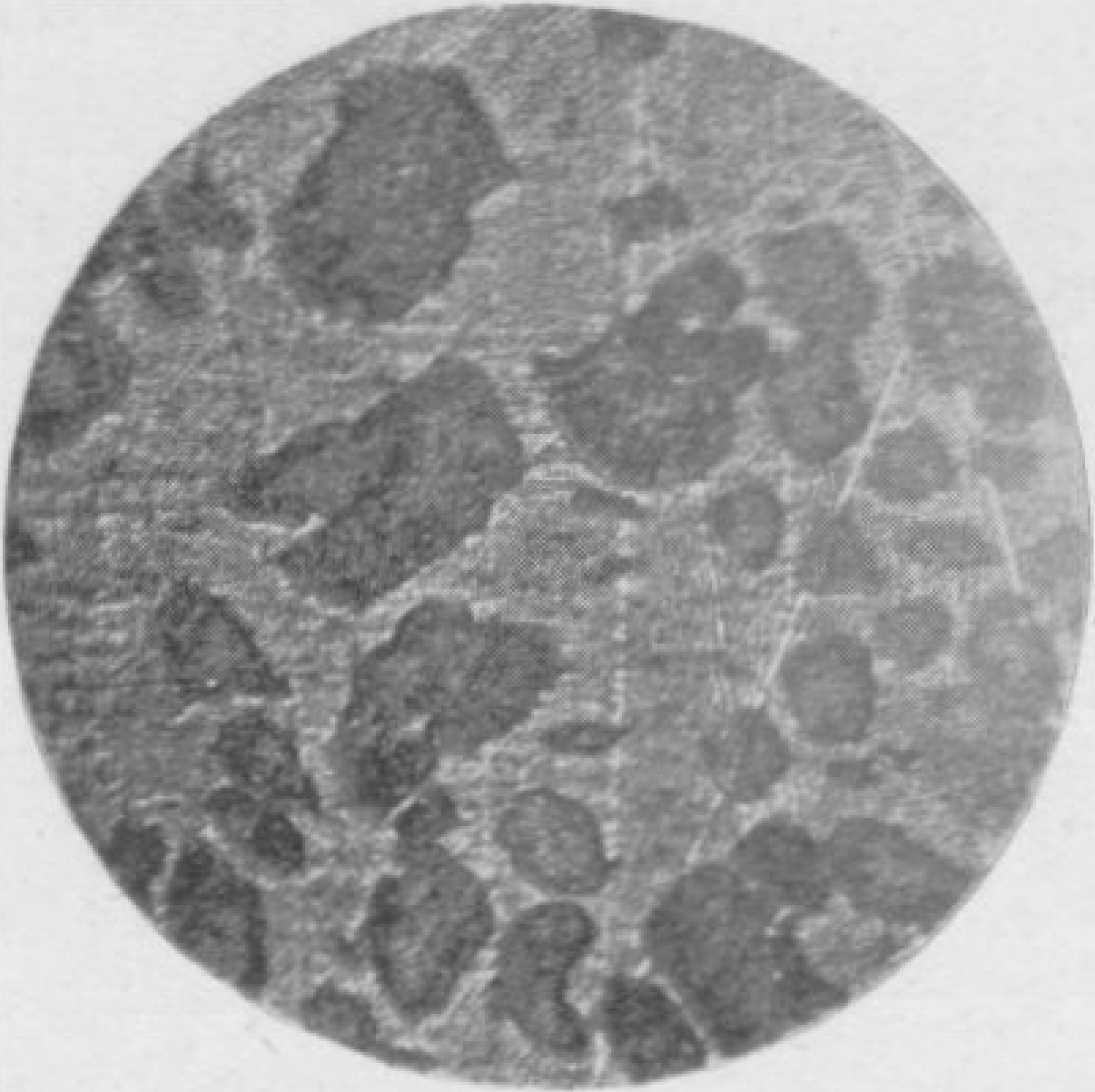

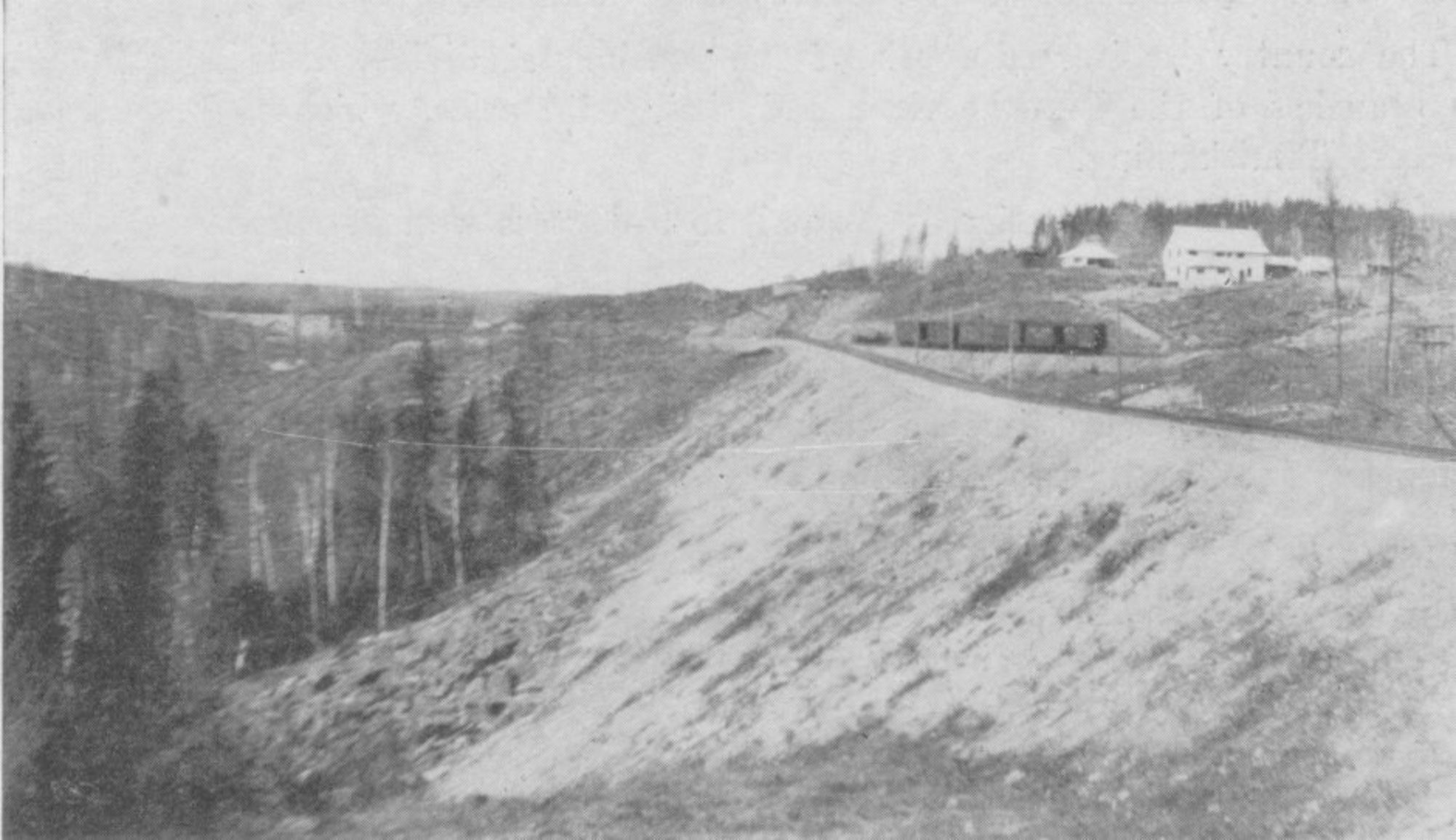

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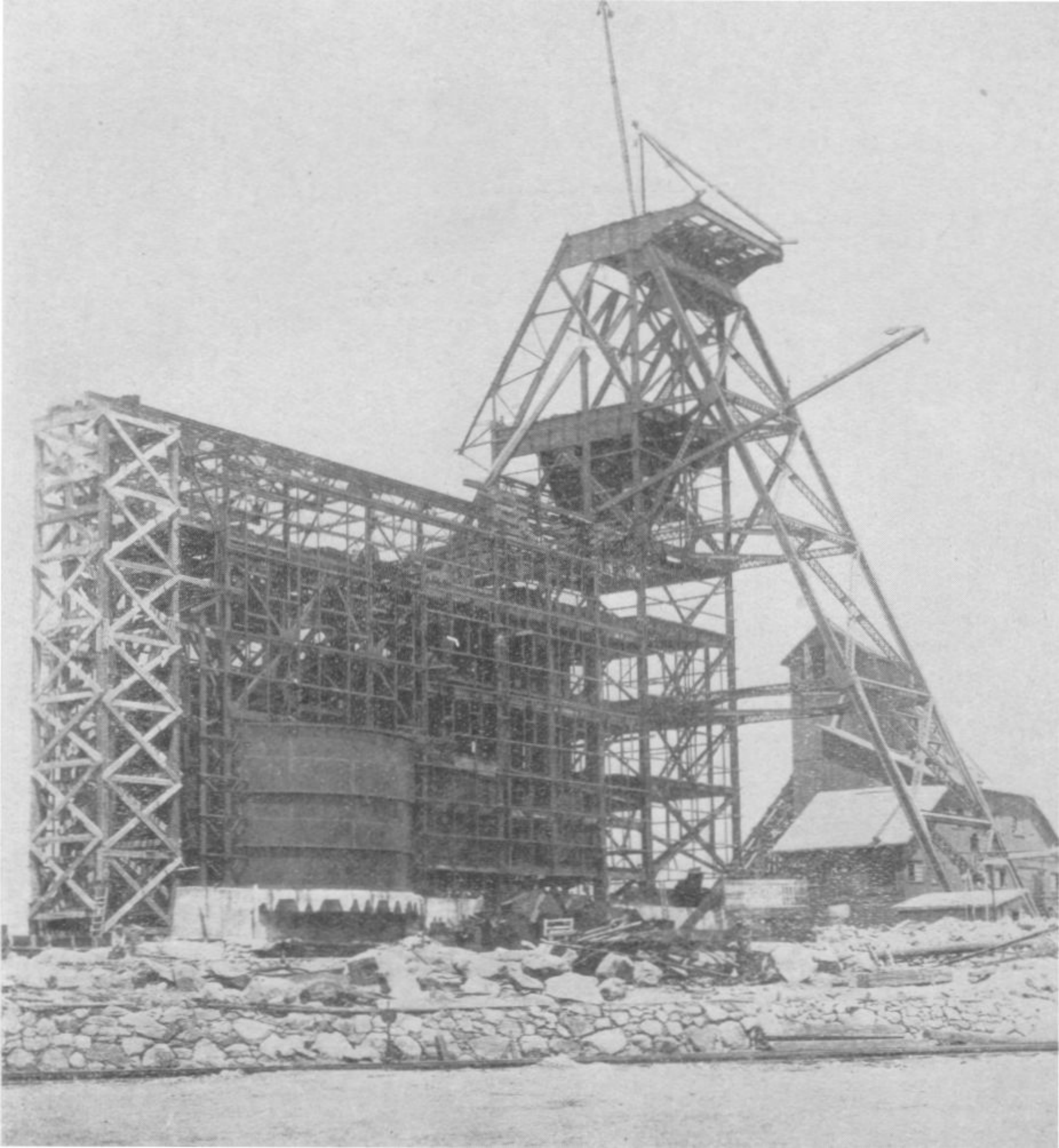

TWENTY-FIFTH ANNUAL REPORT

OF THE

ONTARIO BUREAU OF MINES, 1916,

BEING

VOL. XXV., PART II.

LEAD AND ZINC DEPOSITS IN ONTARIO

AND IN

EASTERN CANADA

By

W. L. UGLOW

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

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CONTENTS

PAGE

Introduction 1
Area Covered and Nature of Work.... 1
Classification and Description of Deposits 1

1. Origin probably dependent on igneous after-action 2
A. High-temperature deposits 3
(1) Notre-Dame-des-Anges deposits, Quebec 3
(2) Calumet Island deposits, Quebec 5
(3) Zenith Zinc mine, Ontario. 7
(4) Gesic Zinc mine, Ontario... 9
(5) Faribault Brook Zinc prospect, Nova Scotia 9
(6) St. Francis, Beauce county, Quebec 9
(7) Ruel Zinc prospect, Ontario 9
(8) Sahkatawichtah (Rush) Lake deposit, Ontario 10
B. Intermediate-temperature deposits 10
(1) Barrie township, Frontenac county, Ontario 11
(2) McKinnon vein, Atikokan, Ontario 11
(3) Black River deposit, Lake Superior, Ontario 12
(4) Granite Islet deposit, Lake Superior, Ontario 12
(5) Poirier Lake, Timiskaming county, Quebec 12
(6) Elmtree prospect, New Brunswick 13
(7) Victoria mine, Algoma district, Ontario 13
(8) Cascade mine, Algoma district, Ontario 14
(9) Wright mine, Timiskaming county, Quebec 14
(10) Lead Hills location, Lake Superior, Ontario 15
(11) Lady Evelyn and Haycock deposits, Ontario 15
(12) Bourke deposits, Timiskaming district, Ontario... 16
(13) Pie Island deposits, Lake Superior, Ontario 16
(14) Sudbury deposits, Ontario.. 17

2. Origin probably independent of igneous after-action—low-temperature deposits 17
A. Calcite - barite - fluorite - galena veins 18
(1) Frontenac Lead mine, Ontario 18

PAGE

(2) Chats Island deposits, Ontario 21
(A) Galetta Lead mine.. 21
(B) Campbell's prospect. 22
(3) Hollandia Lead mine, Ontario 23
(4) Katherine Lead and Zinc mine, Ontario 24
(5) Bedford Lead prospects, Ontario 25
(6) Union Creek Lead mine, Ontario 26
(7) Crown King Lead prospect, Ontario 26
(8) Ramsay Lead mine, Ontario 27
(9) Lansdowne Lead veins, Ontario 28
(10) Tudor Group of Lead veins, Ontario 28
(11) Lake Group of Lead veins, Ontario 29
(12) Methuen Lead vein, Ontario 29
(13) Storrington Lead vein, Ontario 29
(14) Other localities in which similar calcite-barite-galena veins are found in Ontario. 30
(15) Hull Lead veins, Quebec... 30
(16) Buckingham Lead veins, Quebec 30
(17) Indian Cove Lead veins, Quebec 31
(18) Little Gaspe Cove Lead veins, Quebec 31
(19) Baie-St. Paul Lead veins, Quebec 32
(20) Petite-Nation River Lead veins, Quebec 32
(21) Rossie Lead veins, New York state 32
(22) Redwood Lead vein, New York state 33
(23) Smithfield mine, Nova Scotia 33
(24) Lake Superior Group of deposits, Ontario 33
(a) Silver Lake location. 34
(b) Island No. 2, Silver Lake 34
(c) Paresseux Rapids, Kaministikwia River. 34
(d) Blende Lake, Thunder Bay 34
(e) Location VI L, Black Bay 35
(f) St. Clair location, Black Bay 35
(g) Enterprise mine, Black Bay 35

PAGE

(h) McKellar Island, Thunder Bay ....
(i) Dorion Township, Black Bay ....
(j) Dorion Zinc and Lead mine, Dorion Tp. ... 35
B. Origin of the calcite-barite-fluorite-galena veins 36
Hypothesis of Origin by Meteoric waters 38
Probable Origin of the Fluorite. 39
Vein Fillings of Fault Fissures 40
C. Gash veins and impregnations in Paleozoic limestones 42
(1) Albemarle Zinc mine, Ontario 42
(2) Lake Mistassini, Quebec... 42
3. Anamorphosed low-temperature deposits 43

PAGE

(1) Long Lake Zinc mine, Ontario 44
(2) Sheffield Township Zinc deposit, Ontario 48
Bounties on Lead and Zinc produced in Canada 48
Lead Bounty 48
Zinc Bounty 49
Production and Consumption of Lead and Zinc in Canada 50
Lead 50
Zinc 50
Duties on Zinc and Lead: Canada and United States 51
Conclusion 51

MAPS

No. 25b.—Map of part of Ontario, showing location of zinc and lead deposits ....*In pocket.*
No. 25c.—Map of portion of Ontario, showing relation of galena-calcite-barite veins to major elements of geologic structure .....*In pocket.*

FIGURES

PAGE

Fig. 1.—Sketch showing occurrence of ore at Notre-Dame-des-Anges 4
Fig. 2.—Frontenac Lead mine 20
Fig. 3.—Long Lake Zinc mine 46

LEAD AND ZINC DEPOSITS IN ONTARIO

AND IN

EASTERN CANADA

By W. L. UGLOW

INTRODUCTION

During the period from October, 1914, to July, 1915, the writer was employed by private interests in making a study of the deposits of zinc and lead minerals, from the point of view of their economic value, that occur in the general region lying between Quebec city on the east and Sudbury on the west. On account of the nature of the work, the details and results of the exploration have been, until the time of publication of this report, private property. Recently, however, the unusual developments in the zinc and lead markets, due to military and other similar requirements, have caused at least a temporary abandonment of the work. Considerable information had been collected by the writer during that period, both as a result of field examinations and from an extended perusal of the literature; and acting upon the suggestion of the Provincial Geologist, the writer obtained permission to embody portions of the data in a report to the Bureau of Mines, for the benefit of the general and mining public. The report is prepared in the hope that it may stimulate prospecting and development, and that it may direct attention to those types of deposits which appear to give promise of developing into bodies of commercial importance.

AREA COVERED AND NATURE OF WORK

Field examination of mineral properties was limited to those that occur west of Quebec city and east of the western end of the Sudbury basin. Within this area, special attention was given to occurrences in the southeastern part of Ontario, that is, south of the Ottawa and French rivers. Geological literature was closely searched for descriptions of these and all other Ontario and Quebec deposits, and a great deal of valuable information was obtained from some of the earliest of the publications of the Geological Survey of Canada. As a general rule deposits located more than seven or eight miles from transportation were not examined by the writer, except in cases where descriptions and reported assays suggested that the deposits were of more than average value.

CLASSIFICATION AND DESCRIPTION OF DEPOSITS

Various well-marked types of zinc and lead deposits occur in eastern Canada. For the purpose of description and comparison, a classification of these deposits is here attempted, based on the same general principles as those adopted by Dr. Waldemar Lindgren in his work on "Mineral Deposits." In many cases, com-

plete descriptions of the deposits are lacking, and places have been assigned to them in the classification based entirely on inferences drawn from the nature of the associated ore and gangue minerals.

The chief divisions of the classification used in this report are as follows:

1. *Origin probably dependent on igneous after-action.*

    A. High-temperature deposits.
    B. Intermediate-temperature deposits.

2. *Origin probably independent of igneous after-action. Low-temperature deposits.*

    A. Calcite-barite-fluorite-galena veins.
    B. Origin of the calcite-barite-fluorite-galena veins.
    C. Gash veins and impregnations in Paleozoic limestones.

3. *Anamorphosed low-temperature deposits.*

A simple genetic classification has been selected for the purposes of this report for three chief reasons; first, because the deposits seem to fall naturally into genetic groups; second, because a genetic classification has its basis in the conditions of origin of the deposits; and third, because in exploration and development work, the engineer can follow up the ore bodies to much better advantage if he can form an idea of their mode of origin.

Although a great many of the deposits are of very distinct types, and fall definitely into one or other of the chief divisions of the classification, there are other deposits which occupy intermediate or transitional positions. For the sake of convenience these are discussed under the heading of the division which they most closely resemble. Lead and zinc deposits are taken up together, that is to say, there is no grouping of deposits into those of lead and those of zinc. Minerals of both of these metals are found in all the deposits, and this is in accordance with the general situation in other parts of the world. Certain deposits of the area under discussion have zinc minerals in predominance, others have chiefly lead minerals, while a few occurrences have intimate mixtures of both. Consequently confusion would be the result of an attempt to make the metalliferous content of the ores anything but a very minor feature of the classification.

1.—Origin Probably Dependent on Igneous After-action

In this major division are included those deposits whose mineralogical composition suggests that they have originated from hot ascending solutions which were charged to a greater or less degree with materials usually conceived to have been derived from igneous emanations. Where such deposits have been thoroughly studied in other districts, it has generally been found that they occur in or near igneous rock, which was probably the source of the emanations. In the Eastern Canada area, however, sufficient detailed geological work has not been done in connection with the various deposits to warrant the statement that the ore and associated minerals are definitely due to magmatic or meteoric causes. In most cases, the association of minerals, rather than the areal geology, is the criterion

used in establishing the place of a deposit in the genetic classification. Several of the deposits which are included under the heading (1B) are placed there, because the form of the deposit and its mineralogical composition are very similar to those of certain western deposits whose geology and genetic relations to intrusives have been very carefully worked out.

In this chief division there are two fairly well-defined groups of deposits.

A.—HIGH-TEMPERATURE DEPOSITS

This group includes deposits of deep-seated origin, both veins and replacements, the latter possibly of contact metasomatic nature. The temperature, at the time of their formation, was, according to Dr. Lindgren, probably between 300°C. and 800°C., but in most cases below 575°C.; the pressure was very high. These conditions are indicated by the presence of such minerals as pyrrhotite, garnets, pyroxenes, epidote, biotite, and lime-alumina silicates generally. According to E. T. Allen[1] pyrrhotite can be readily formed by the decomposition of pyrite in hydrogen sulphide at temperatures above 575°C. The higher the temperature is carried, the more sulphur is lost, and a product formed at high temperatures, say 800° to 1,100°C., takes up more sulphur when heated in hydrogen sulphide below that temperature. In the neighbourhood of contact intrusive masses, where the sulphides of iron occur, pyrrhotite is found close to the contact where the temperature was highest, and pyrite in the colder zones. It is commonly held by geologists that in nature pyrrhotite was formed from the same solution as silicates like olivine and augite. Garnets, diopside, and other lime-alumina silicates are high-temperature minerals[2] and are found in nature commonly around intrusive contacts or in vein deposits of high-temperature origin. A complexity of mineral composition frequently characterizes these deposits; and intimate mixtures of the ore and gangue minerals, and of sulphides with oxides, is considered a fairly safe criterion of high-temperature origin.

(1) *Notre-Dame-des-Anges, Portneuf county, Que.—(Zinc).*

(*a*) Location: The deposits, which are two in number, occur at distances of two and four miles south of Notre-Dame-des-Anges station on the Canadian Northern Quebec railway, in the township of Montauban, county of Portneuf, Quebec, and about forty-five miles west of Quebec city.

The more important deposit is at a distance of four miles from the village, and occurs in lots 37 to 46, range I of Montauban township. The other deposit is located about two miles from the village, and occurs in lots 6, 7, 8, of range IV of the same township.

(*b*) Ownership: The first-named deposit was opened up by Pierre Tetreault, of Montreal, who recently leased 1,000 feet along the outcrop of his vein to the Weedon Mining Co., of Sherbrooke, Quebec. North of the Tetreault line, the Laurentide Company had, at the time of the writer's examination in November, 1914, explored the continuation of the deposit for a distance of about 2,300 feet.

[1] E. T. Allen: "Studies in Ore Deposition, with Special Reference to the Sulphides of Iron," Wash. Acad. Sci., Jour., Vol. I, No. 6, pp. 170-177, Oct., 1911.
[2] A. Harker: "The Natural History of Igneous Rocks," p. 283.

The deposit located in range IV, lots 6, 7, 8 was also controlled by the Laurentide Company.

(*c*) Geology: The deposits occur within the area of the pre-Cambrian shield. The country rocks consist of a series of interbedded white quartzites, micaceous quartzites, gneisses of probable sedimentary origin, calcareous schists, with less extensive beds of white crystalline limestone. This series of thinly and thickly bedded sediments strikes from N. 20° E. to N. 30° E., magnetic, and dips from 15° to 40° S.E. In the immediate neighbourhood of the deposits, rock exposures are not abundant. Intrusive igneous rocks were not seen, although T. C. Denis, Superintendent of Mines for the Province of Quebec, states[3] that pyroxenite intrudes the gneisses and limestones. The sedimentary series is remarkably uniform in strike, but changes in dip are frequent, due to minor folding within the less competent layers.

(*d*) Ore minerals: The chief ore minerals are ferriferous zinc blende, of which a pure specimen might assay from 50 to 55 per cent. zinc. This mineral occurs sometimes in large cleavable grains, comparatively free from other minerals; but the usual occurrence is an association, often very intimate, of the ferriferous blende with smaller amounts of galena, pyrite, pyrrhotite and chalcopyrite. In the leaner portions of the ore body, pyrite and pyrrhotite are more conspicuous. The ore was said to show good values in gold and silver, although assays were unobtainable at the time.

(*e*) Gangue minerals: The chief gangue consists of the country rock, which is largely quartzite. Quite abundant, however, are garnets, biotite, diopside, amphibole and quartz. The presence of lime-alumina silicates in intimate association with the ore minerals is good evidence of high-temperature origin.

(*f*) Occurrence of the ore: In each of the two deposits mentioned, the ore occurs in two well-defined zones, each parallel to the strike of the sedimentary series. Within these series, the ore is found as fillings of gash veins and impregnations in a micaceous quartzite member, and to a less extent as impregnations in crystalline limestone.

The mineralized zones vary from a few inches to at least forty feet in thickness. They follow definite horizons in the sediments, both along the strike and down the dip. The typical occurrence seems to be as fillings of gash fissures, produced by the folding and shearing of the beds. The following sketch (Fig. 1) shows in plan and vertical cross-section the habit of the gash veins. As far as

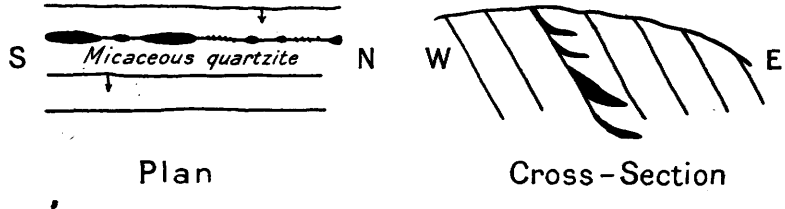

Fig 1—Sketch showing occurrence of ore (in solid black) at Notre-Dame-des-Anges.

[3] Report on the Mining Operations of the Province of Quebec, 1912, p. 29.

could be determined at the time of the writer's examination, these veins, especially the smaller ones, followed down the footwall of the micaceous quartzite for a certain distance, and then flattened off towards the hanging wall. By the continuation of a shaft down the footwall, other veins would be encountered, which would also flatten off towards the hanging wall. This occurrence was specially noticeable at one of the shafts of the Laurentide Company, where several of these small veins had been intersected in this manner.

The Tetreault Company had sunk inclined shafts on two very promising outcrops. In one of these the ore was thirty-six feet in width and was practically solid. The shafts were in the neighbourhood of 100 feet in depth, and were still in the same ore vein or lens. It is presumed that these bodies or lenses of ore were simply fillings of large gash fissures, similar to those found on the Laurentide property. A great many of these gash veins are bounded by a distinctly marked micaceous gouge, which varies in thickness with that of the vein. In other cases the ore is firmly "frozen" to the wall. This gouge does not necessarily mark the wall of the ore body, for impregnations of the ore minerals occur throughout the country rock, outside of the veins, but within the general ore horizon.

Along the strike of the mineralized zone, the ore is seen to occur intermittently. Bodies of high-grade ore were uncovered at the surface at two or three points, but these lensed out along the strike. This is good evidence that the same situation will occur as the ore is followed down the dip. Between the outcrops of high-grade ore, the ore horizon is usually quite lean, in places showing only a slight dissemination of the ore minerals, and in other places a few narrow gash veins.

The ore occurs throughout the mineralized zones in two types: first, a coarse-grained, cleavable type within the larger veins, which consists very largely of ferriferous blende with only minor amounts of the other metallic minerals. This affords a very desirable product, and one that assays upwards of 50 per cent. in zinc. The second and more common type is known as the complex ore, and consists of a very intimate and somewhat fine-grained mixture of ferriferous blende, galena and pyrite with minor amounts of chalcopyrite and pyrrhotite. With this type the gangue minerals are usually rather abundantly associated. Pink garnets, biotite and quartz may very commonly be seen embedded in a solid mixture of the metallic minerals.

(*g*) Genesis of the ore: From the presence of pyrrhotite, garnet and biotite, in intimate association with the ore minerals, from the gold and silver values in the ore, and from the nature of the intimate mixtures of metallic minerals, it is suggested that the deposit is of high-temperature origin, and was formed at great depths under conditions similar to those of contact metasomatism. There is nothing that would indicate a change of values with moderate depth.

(2) *Calumet Island, Ottawa River, Que.—(Zinc-Lead)*

(*a*) Location: Calumet island is formed by two channels of the Ottawa river and is situated some fifty miles above the city of Ottawa. The chief deposits occur near the southern end of the island in lots 3 to 12, range IV. The nearest railway station is Campbell Bay on the Ottawa-Waltham line of the Canadian Pacific railway.

(*b*) Ownership and history:

Some mining was carried on in the island in the early nineties, when several tons of ore were extracted on lots 10 and 11, range IV. . . . In 1897 and 1898, the Grand

Calumet Mining Company went on with the work, and several hundred tons of ore, mined from lots 9 and 10, range IV, were shipped to Belgium. In 1907 some exploratory work was carried on by a United States syndicate. The option, however, was not exercised.[4]

In 1910 the Calumet Metals Company was formed, and work since that time has been confined to surface development, prospecting, and to the extension of the old workings in the Bowie and Lawn shafts. In 1912, a concentrating mill to treat 150 tons per twenty-four hours had been installed, but was not operated steadily. The mill is equipped with jaw crushers, coarse rolls, screens, fine rolls, jigs, Huntingdon mill, Wilfley and Overstrom tables.[5]

At the time of the writer's examination of the property, it was closed down and the shafts were full of water. The chief owner at the time was Mrs. Reeder of New York, and there seemed to be but slight chance of the owners again opening it up, or of any other company gaining control either by purchase or lease.

(*c*) Geology: In the immediate vicinity of the deposits, the rocks consist of an interbedded series of sericitic quartzites, micaceous gneisses of probable sedimentary origin, and crystalline limestones, striking in a northwest-southeast direction, and dipping usually at various angles towards the northeast. The rocks resemble very closely those at Notre-Dame-des-Anges, Quebec, but they are considerably more deformed and schistose. Minor folding and faulting were frequently noticed. Within a few miles of the mine, large areas of crystalline limestone were seen, intruded by granite and gabbro.

(*d*) Ore minerals: These are also very similar to those found at Notre-Dame-des-Anges. In certain parts of the property, chiefly towards the southeast, the chief ore mineral is ferriferous blende. Towards the northwest end, argentiferous galena is reported to have been quite abundant. The typical ore, however, consists of a rather intimate mixture of these two minerals, and is usually considerably more fine-grained than the mixed ores at Notre-Dame-des-Anges. Native silver was occasionally found. Pyrite, chalcopyrite, magnetite and pyrrhotite, the pyrite sometimes in considerable amount, are associated with the ore minerals.

(*e*) Gangue minerals: The chief gangue consists of the country rock—quartzite, sericite schist, micaceous gneiss, with plentiful amounts of quartz, calcite and lime-alumina silicates.

(*f*) Occurrence of the ore: The ore occurs as a series of lenticular deposits of the gash-vein type within the quartzite and gneiss, and also less noticeably as impregnations in these rocks as well as in the crystalline limestones. Two zones of mineralization occur. Each is parallel to the strike of the rocks, and separated from the other by only a few hundred feet. The walls of the individual lenses do not seem to be very well defined, as in the case of the Notre-Dame-des-Anges deposits, and ore minerals are irregularly disseminated in small bunches here and there through the rocks in the general ore horizon. The mineralization along the strike appears to be decidedly intermittent, and mineralized portions are separated from each other by barren stretches. Underground development has shown that in vertical section the individual lenses come in and pinch out exactly as they do along the strike in a horizontal section.

[4] Mining Operations in the Province of Quebec, 1911, pp. 27-28; Idem, 1912, p. 29.
[5] Geol. Sur. of Can., Ann. Rept., N.S., Vol. XV, 1902-3, p. 243 S.

Six shafts have been opened up on the property, and the greatest width of ore body discovered is said to be twenty feet. The greatest depth attained in the development is said to be 120 feet. All of the dumps show the presence of ore minerals, and an average assay of them from samples taken in 1911 by C. W. Willimott of the Geological Survey gave the following results:

Silver : 14.50 oz. per ton of 2,000 lb.
Zinc : 29.19 per cent.
Lead : 13.75 " "
Copper: 3.17 " "

(*g*) Genesis of the ore: The criteria of origin are much the same in this deposit as in the similar one at Notre-Dame-des-Anges. At the Grand Calumet property, the presence of lime-alumina silicates, pyrrhotite, and magnetite is significant of high-temperature origin, but the absence of garnets, so abundant at Notre-Dame-des-Anges, is here quite noticeable.

(*h*) Treatment: The intimate association of the galena and zinc blende has made the concentration problem a rather difficult one, but modern methods of selective leaching and electrolytic precipitation of the zinc from such mixtures ought greatly to simplify the treatment.

Other deposits of a similar nature have been reported from this general locality, but they were not investigated by the writer.

(3) *Zenith Zinc Mine, Rossport, Ont.*

(*a*) Location: The Zenith mine consists of location 30T., which has an area of 160 acres, and is situated 13 miles north of the transcontinental line of the Canadian Pacific railway, near Rossport on the north shore of lake Superior. The road to the mine leaves the railway five miles east of Rossport, at a point where a siding known as "Zinc Siding" has been constructed for the shipment of ore. Winston flag station 1½ miles east of the siding, is the nearest point where the regular train stops. The road to the mine is only a winter road as thirteen small lakes are crossed.[6]

(*b*) Ownership: The mine is owned by the Grand Calumet Mining Company, Limited, of Ottawa: President, W. J. Poupore.[6]

(*c*) Geology: The deposits seem to consist of more or less irregular bodies of sphalerite in the hornblendic and dioritic Huronian rocks of the vicinity.[7]

(*d*) Occurrence of the Ore: The ore exposures consist of one on the top of a hill on the one side, and another near the base on the other side, near the shore of a little lake. The hill is about seventy-five feet in height above the lake level. At neither point had the limit of the ore been shown in any direction, and therefore such features as the strike, dip and thickness could not definitely be determined. At the lower workings a surface of solid ore had been exposed, measuring about 20 feet x 15 feet, a smaller exposure about 90 feet to the southeast of this measuring 10 feet x 10 feet. Easterly from the main stripping about 30 feet, outcroppings seem to show the existence of a small vein about six inches thick striking about N.E., dipping 45° N.W., and a small parallel vein shows about 15 feet further west again. The upper workings are some 500 feet north of these. At the time of the visit above mentioned (1884) a surface of solid blende about 15 feet x 20 feet had been exposed by stripping. The formation strikes about W.N.W. and dips northerly about 50°. In an easterly direction from the exposure the ore if continuous must underlie a capping of country rock. Although no final opinion could be formed at that time and under

[6] Ont. Bur. Mines, Vol. IX, 1900, p. 86. [7] Geol. Sur. Can., Ann. Rept., N.S., Vol. XV, 1902-3, pp. 244-247 S.

the conditions then existent, the impression was formed, from the features presented on the ground, and from the minute structure of some of the ore, that it probably exists as masses coinciding with the foliation of the country rock, and would thus follow it in all its flexures. If this be the case, one would expect in the sharper bends to find large irregular masses of ore connecting with thinner sheets in the less folded portions. This supposition would explain the peculiar features of the ore surfaces above mentioned, especially the upper ore, where it would appear as if the prospectors had uncovered one of these bends from above by stripping off the overlying rock representing the upper portion of a fold.[7]

In the open cut, a large body of zinc blende was struck and stoped up 15 feet to the surface, in places four and five feet wide, but of very irregular shape, and without any visible continuous walls. At 12 feet in the tunnel another band of solid blende a foot wide runs down into the floor, and at 30 feet beyond this is a third body, 15 inches wide at first but pinching out in ten feet at the base. Besides these three main strikes, many other intermediate stringers and veins from a fraction to ten inches wide were passed, all having approximately the same strike of north and south and dip of about 25° east, into the hill, which bearings coincide with those of the outcropping of the large vein at the surface above. The country rock, as seen in the tunnel, has been disturbed and broken up along two directions, giving it a "blocky" appearance, the main movement having been sufficient to produce schistose areas in widths from streaks up to several feet, striking north and south with dip 25° east, which directions are the same as those of the ore bodies. In fact it is in this schist, altered in places from the coarse green trap rock to a soft gouge, that most of the veins have been found.[8]

(*e*) Nature of the Ore: The blende is dark coloured and the associated minerals noticed were copper and iron pyrites and here and there a little dendritic native copper, also a white incrustation on the weathered surface, probably sulphate of zinc from oxidation of the ore.[7]

Grains of zinc blende occur imbedded in the massive trap, having no connection with the main deposits; frequently also masses of the sulphides, pyrites, pyrrhotite and chalcopyrite are exposed in the seams, both separate from and contiguous to the blende. The massive zinc blende in the tunnel workings contains small grains of pyrites and pyrrhotite disseminated uniformly throughout it, forming but a small percentage of the whole yet in considerably greater quantity than is found in the very coarse blende at the old surface stope.[8]

A specimen of the ore from this place supplied to the chemical branch of the Survey by Dr. R. Bell gave 54.26 per cent. of metallic zinc. The average of the ore shipped, however, is said to have run about 45 per cent.[7]

(*f*) Development: Although the existence of ore at this place was known more than twenty years ago, owing to its inaccessibility it was not worked until the winter of 1898-99. Operations were then continued on and off for a year or two, but the mine is now idle. The total amount of ore shipped as per returns received at this office, was 1,065 short tons. The latest description of the progress made at the time is given in the report of the Ontario Government Inspector of Mines as follows:—To Feb. 21, 1900, three shafts had been sunk; No. 1, 35 feet deep; No. 2, 40 feet deep; No. 3, 12 feet deep. A small open cut had also been made, from which about 100 tons of ore had been taken. All the shipments were made in the winter by hauling the ore over the ice on the lakes and on the connecting stretches of road which had been cut out for the purpose. Freighting from the mine to the railroad is said to have cost about $2.00 per ton.[7]

Speaking of his visit to this place on Feb. 14, 1901, the Mining Inspector describes the condition of things as follows:—

Mining operations since a year ago have been confined to driving a tunnel into the hill in which the zinc blende deposits occur, starting on the level of the small lake at the foot at a point between the old shafts, about 100 feet north of No. 1 and 500 feet south of No. 2, and beneath the old open stope in the brow of the bluff. The length to date is 75 feet, including 18 feet of open cut at the mouth, and in its course of about northeast, the tunnel is intended to cross-cut to the main veins found on the surface as well as to explore the country rock.[8]

(*g*) Genesis of the ore: Although the above descriptions from the point of view of genesis are not very satisfactory, it seems reasonable to conclude that the deposit, from its occurrence in close association with igneous rocks, from the

[6] Ont. Bur. Mines, Vol. IX, 1900, p. 86. [7] Geol. Sur. Can., Ann. Rept., N.S., Vol. XV, 1902-3, pp. 244-247 S. [8] Ont. Bur. Mines, Vol. X, 1901, p. 110.

association of pyrrhotite with the ore mineral, and from the dissemination of grains of sphalerite throughout the massive trap, belongs to this main division, and was formed under conditions of high temperature and pressure as a more or less direct result of igneous emanations.

(4) *Gesic Zinc Mine, Ont.*

Little information beyond what is contained in the following quotation could be found with regard to the property. It is placed in this division on account of its supposed similarity to the Zenith mine:—

The Gesic mine is about two miles south of the Zenith, on the same road. There are ten locations, aggregating 400 acres. The owners are W. A. Johnson, C. Palmer and J. Hare of Toronto, who are forming a stock company to take the property over. . . . I visited the property on Feb. 22, and found operations in progress on location ES 79. A test shaft with a dip of 50° or 60° north had been sunk 23 feet on the vein and was being continued. The formation is trap; the vein is said to be traceable over several locations, with a strike of east and west. At the surface of the pit there is very little mineralization; in fact the vein appears to consist of only a sheared zone of country rock. But at the bottom of the shaft zinc blende is making its appearance in promising quantities.[9]

(5) *Faribault Brook Zinc Prospect, Inverness county, C.B.*

The following description is given by F. H. Mason, Analyst, of Halifax, N.S., and is quoted in the Annual Report of the Geological Survey of Canada, Volume XV, N.S., 1906, page 242 S:—

The only deposit of zinc blende that has any economic possibilities that I know of in Nova Scotia, is that owned by the Cheticamp Gold Mining Company situated at Faribault brook, a branch of the Cheticamp river, Inverness county, C.B. It occurs in a bed of sericite schist some 20 feet in thickness and is associated with pyrrhotite, mispickel and galena. The mineral occurs in bands through the schist, and is in places quite massive. I have seen lenses over two feet in thickness. A slope 45 feet deep has been sunk upon it. I have found that by crushing to about ¼-mesh and roasting prior to concentration a fairly clean galena and blende concentrate may be obtained.

Genesis of the ore: The association of the sphalerite with pyrrhotite and mispickel suggests a high-temperature origin for the deposit.

(6) *St. Francis, Beauce county, Que.—(Silver-lead-zinc)*

A vein which occurs at the rapids of the Chaudière in St. Francis, Beauce county, contains, in a gangue of quartz, argentiferous galena, blende, mispickel, besides cubic and magnetic pyrites, with minute grains of native gold. A portion of galena from the assorted and washed ore, which still retained an admixture of blende and pyrites, gave by assay sixty-nine per cent. of lead, and thirty-two ounces of silver to the ton of 2,240 pounds of ore.[10]

(7) *Ruel Zinc Prospect, Marshay township, near Ruel, Ont.*

(*a*) Location: This property is situated four miles southwest of Felix, on the Canadian Northern Ontario railway, about fifty-six miles by rail north of Sudbury, and about eight miles south of Ruel station. A bush trail from Felix leads to the property.

[9] Ont. Bur. Mines, Vol. IX, 1900, p. 87.
[10] Geology of Canada, 1863, p. 517.

(*b*) Occurrence and nature of the ore: The country rock is a massive greenstone or altered gabbro, associated with a lean greenish carbonate phase of the iron formation. The latter strikes about east and west. The ore is a very fine-grained intimate mixture of galena and sphalerite, occurring in at least two zones parallel to the strike of the country rock. Pyrrhotite occurs in places, as well as pyrite and traces of chalcopyrite. The ore minerals seem to be of the nature of an impregnation in the greenstone and the iron formation. The galena occurs generally in very narrow vein-like stringers cutting through the blende. The ore is not usually clean, but contains bunches of barren rock scattered through it. It is reported that pyrrhotite was the original discovery, and that on sinking, zinc blende was encountered. The bottom of the shaft is reported to be in high-grade sphalerite.

(*c*) Extent and development: A shaft reported to be sixty feet deep, but full of water at the time of the writer's examination, and six surface trenches, constitute the total development on the property. Traces of the ore may be seen in a general east-west direction across three claims, but continuous development has not proved more than about 250 feet of ore deposit.

(8) *Sahkatawichtah * Lake Deposit—(Lead)*

Fine-grained galena ore has been recently found in drilling operations in an iron formation belt south of lake Sahkatawichtah in the Sudbury district, Ontario. The location is about ten miles south of the Canadian Northern Ontario railway and about twenty-nine miles south of Flying Post. Details of the occurrence are lacking, but it is suggested that it may be of the same type as the Ruel deposit discussed above.

B.—INTERMEDIATE-TEMPERATURE DEPOSITS

This group is intended to include a variety of deposits which are believed to have originated at considerable depth below the surface. They occupy in some respects a transitional position between the deposits of high-temperature origin and those believed to have been formed rather near the surface. In their mineralogical composition the direct effect of igneous emanations is usually very inconspicuous, but a group of minerals is found in their make-up that is very suggestive of a derivation from hot ascending solutions, which may have obtained part of their load in some manner from contact with heated igneous rocks.

As mentioned on page 3, many of the deposits herewith described are placed in this group because of their resemblance in structure and composition to well-known deposits of western United States and Canada, whose genetic relations to igneous action have been quite thoroughly worked out.

The chief metallic minerals occurring in deposits of this nature are sphalerite, galena, pyrite, chalcopyrite and tetrahedrite. The ores usually carry recoverable values in silver and gold. The predominating gangue mineral is quartz, but carbonates are also common, such as calcite and dolomite. The deposits are marked by the absence of such minerals as pyrrhotite, magnetite, specularite, biotite, pyroxene, garnet and other lime-alumina silicates.

* Also known as Rush lake.

The deposits normally fill rather well-marked fractures, indicating that they were formed within the zone of fracture. According to Dr. Lindgren, the temperature of formation of this division of deposits ranged from 150° to 300°C.

Certain deposits are described under this heading which resemble in some respects the low-temperature deposits of the succeeding division, and in other respects those of the intermediate-temperature group. On account of the fact that the so-called low-temperature deposits discussed in this paper seem to form a well-marked lithological and morphological group, these deposits of transitional type are discussed at the present stage in the classification.

(1) *Barrie Township, Frontenac County, Ont.—(Argentiferous galena)*

(*a*) Location: Several openings have been made on both sides of the road from Myer Cave to Ardoch, and near the portage to Whitefish lake a short distance south of Perry. The chief deposits occur on lots 9 to 12 in concession VIII.

(*b*) Geology: The rocks consist of a steeply-dipping series of pre-Cambrian sediments striking about N. 50° E., magnetic, and consisting of finely-crystalline, bluish, slaty limestone, sheared pseudo-conglomerate, and mica schist. The series is intruded in several places by granite, and it is in the general vicinity of the intrusives that the ore minerals occur.

(c) Character of the ore and gangue minerals: The ore minerals consist of fine-grained argentiferous galena, pyrite, chalcopyrite and zinc blende. The gangue consists chiefly of a mixture of quartz and calcite.

Several assays of the ore from this place were made in the laboratory of the Geological Survey, the percentage [= quantity] of silver, in one case from a sample from lot 12 of rather coarsely crystalline galena, being 137.883 ounces to the ton of 2,000 pounds and a trace of gold, while a sample from lot 9 of the same range gave 119.583 ounces of silver to the ton, but no gold."

(*d*) Occurrence of ore: The ore occurs both as stringers and lenses up to five feet thick, running parallel to the strike of the country rock, and also in a minor degree as an impregnation in the silicified limestones. As a general rule, both the galena and the quartz are very fine-grained.

(*e*) Genesis of the ore: The highly argentiferous nature of the ore, the presence of gold values, the fineness of the grain of the galena, and its association with quartz, suggest that the deposits were formed by heated solutions which had a genetic relation to the intrusive masses in the vicinity.

(*f*) Development: Four shallow shafts, full of water at the time of examination, are on the properties. Very little ore mineral of any commercial value was seen.

(2) *McKinnon Vein, Steeprock Lake, Atikokan, Ont.—(Lead-zinc)*

(*a*) Location: The deposit is located about ten miles northeast of Atikokan station on the Port Arthur-Winnipeg line of the Canadian Northern Ontario railway.

"Geol. Sur. Can., Ann. Rept., N.S., Vol. XIV, Part J, p. 67.

(*b*) Geology: The vein lies within the Archean complex, close to the contact of greenstone schists and intrusive granite. No sedimentary rocks are known in the immediate vicinity. A dike of diabase seems to form one wall of the deposit.

(*c*) Nature of the ore minerals: These consist chiefly of argentiferous galena and zinc blende, with pyrite and minor amounts of chalcopyrite.

(*d*) Nature of the gangue: The ore minerals are associated with a gangue of white sugary quartz.

(*e*) Occurrence of the ore minerals: The deposit is a quartz vein about ten to fifteen feet in width and stripped at the time of examination for a length of about 100 feet. The metallic minerals occur disseminated throughout the vein in rather fine grains and in places quite abundantly.

(3) *Black River Deposit, north shore of Lake Superior—(Lead)*

At a mining location at the mouth of the Black river, to the north of the Slate islands, the Laurentian rocks are seen near their contact with the Huronian schists. Here a vein of quartz occurs in the granitic gneiss. It runs nearly east and west, with a breadth of from one and a half to five feet, and holds galena and iron pyrites. The latter is more abundant near the shore; but about twenty rods beyond, in the hill, the galena predominates. According to Prof. Hadley, this ore is extremely rich in silver; the lead reduced from it containing from two to three per cent. of the precious metal. This galena, according to the same authority, contains a trace of selenium.[12]

(4) *Granite Islet, Black Bay, north shore of Lake Superior—(Lead)*

Veins holding lead ore are found in several localities on the north shore of lake Superior. Some of these traverse the granitic gneiss of the Laurentian series, as on Granite islet, in Black bay, where a vein of twelve inches in breadth carries a considerable quantity of galena in a breccia of fragments of the wall-rock, cemented by drusy crystalline quartz. This ore does not appear to contain much silver.[12]

(5) *Poirier Lake, Timiskaming County, Que.—(Lead-zinc)*

The following description is given by Dr. J. A. Bancroft in a report to the Superintendent of Mines, of the Province of Quebec. The locality mentioned is about 20 miles south of the National Transcontinental railway and about 50 miles east of the Ontario boundary.

About two-thirds of a mile northward from Poirier lake, a rocky ridge, which in part is devoid of trees, rises to an altitude of approximately 100 feet. The ridge extends nearly east and west corresponding to the strike, S. 80° E., of the highly schistose rocks of which it is composed. The schists are traversed by a series of veins or stringers of quartz, frequently containing a little calcite and epidote, and occasionally bearing small amounts of galena, zinc blende, pyrite and a few specks of copper pyrites. Although these veins may seem to recur at widely separated intervals along a definite line, they can seldom be traced for more than a few feet before they become very narrow and finally disappear. They display a maximum width of four feet, but can be traced for only a few yards before they terminate.

A group of mineral claims are situated there, having for their chief centre of attraction a vein, four feet wide, containing a considerable percentage of galena, zinc blende and pyrite, with an occasional particle of copper pyrites in a gangue of calcite and quartz. At the time of our visit, Mr. George Richmond, who made the discovery, was engaged with a few men in sinking a shaft, which had reached a depth of ten feet. A few feet westward from the shaft, the vein pinches out, but stringers of barren quartz occasionally occur in line with its projection; several hundred feet westward one of these quartz veins, about eighteen inches

[12] Geology of Canada, 1863, pp. 689-690.

wide, contains a little galena and zinc blende. For a few yards eastward from the shaft, the bed-rock is covered, but upon reappearing at the surface there is no evidence of the presence of the vein.

Striking S. 80° E. and dipping 87° toward the south, this vein is situated between a small dike of fine-grained diorite on the north and actinolite schist on the south. Although in part distributed through the gangue of calcite and quartz, the galena, zinc blende and pyrite occur chiefly along or adjacent to fractures in the gangue. Of the economic minerals present, galena is the most abundant, zinc blende tends to occur near the walls of the vein, and the pyrite, which is present in very subordinate amount, is crystallized in beautiful, small pyritohedrons. At the bottom of the shaft the vein was seven inches narrower, pyrite was becoming slightly more abundant, and a dike of aplite, three to four inches wide, intersected the southern margin of the vein. In thin section under the microscope this aplite is found to be almost entirely composed of microcrystalline quartz with epidote of bright yellowish-green colour, which apparently has been derived from the alteration of a small amount of feldspar. So analogous is this aplite to similar dikes, which are associated with and genetically related to the "newer diabase" in other districts, that it lends emphasis to a belief that the vein owes its origin to the intrusions of quartz-diabase in the district.

I was informed that after our departure from the district, the shaft was sunk to a depth of forty feet, where there was about eight inches of vein matter in the form of stringers running in all directions.

The body of ore is by no means large enough to even suggest the possibility of its being developed into a mine for lead and zinc. An assay of an excellent sample taken from the shaft at a depth of eight feet, containing small galena, zinc blende and pyrite, shows the presence of 47 cents per ton in silver and not a trace of gold.[13]

(6) *Elmtree Prospect, Bathurst District, N.B.—(Zinc-lead)*

The following description is given by Dr. G. A. Young in a report to the Geological Survey of Canada.

A vein, principally of zinc blende, galena, chalcopyrite, pyrite and country rock, with a width of about 6 feet, is exposed in the bed of Elmtree river, about 5 miles from its mouth. The vein, with a general direction of about NNW, crosses the river at right angles to its course. It is nearly perpendicular, and cuts black slates of the Elmtree formation. On the upstream side it has a rather distinct wall, and there the enclosing slates are but little altered. On the downstream side the slates are considerably altered (silicified?), penetrated by calcite stringers, and partly mineralized, so that the boundary of the vein is not distinct.

As seen in the bed of the stream, the vein, or, since much altered country rock is present, more accurately speaking, the mineralized zone, contains much pyrite and chalcopyrite in narrow, discontinuous veins, some of which are 4 inches or more in width. The sulphides also occur in scattered grains and small aggregates.

On the eastern bank of the stream there is a small pit now filled with water. The dump is of altered wall rock and ore, and it is noticeable that pyrite is less abundantly developed than in the vein as seen in the river bed. The ore consists chiefly of coarsely crystalline, dark zinc blende, coarse galena, coarse pyrite in grains and aggregates, and a relatively small amount of calcite and quartz. The various constituents tend to occur in large and small aggregates, often vein-like, interbanded and intermixed with altered country rock. The relative amounts of zinc blende and galena vary widely, but, in general, the zinc blende predominates.

An assay of a sample collected a number of years ago gave a trace of gold, and 7.197 ounces of silver per ton.[15]

(7) *Victoria Mine, Garden River, Algoma District, Ont.—(Lead)*

This mine is situated near Garden river and about eight miles north of its mouth.

The galena occurs in stringers, grains and small bunches in a belt of green schists, glossy and cleaving in all directions.

[13] Mining Operations in the Province of Quebec, 1911, pp. 201-203.
[15] Geol. Sur. Can., Memoir No. 18, 1911, pp. 75-76.

The galena is argentiferous, and is often mixed with blende and iron and copper pyrites. Analyses made recently of samples . . . gave the following results:

	(1)	(2)
Silver	19.00 oz.	14.5 oz.
Gold	trace	$6.00
Copper	5.62 per cent.	2.20 per cent.
Lead	53.2 "	5.72 "
Zinc	9.76 "	22.8 "

Work on this deposit was commenced in 1875. Shipments were made from 1878 to 1880. Two shafts were sunk, one 410 and the other 100 feet, and drifts and cross-cuts driven. No work is at present in progress.[16]

(8) *Cascade Mine, Garden River, Algoma District, Ont.* [17] [18]—(*Lead*)

From the descriptions referred to in the footnotes, the Cascade mine seems to be on a continuation of the Victoria vein. One shaft was put down to a depth of about 200 feet; some cross-cuts were driven, two levels extended about 200 feet, and some stoping done. The general character of the vein was about the same as that of the neighbouring Victoria mine.

(9) *Wright Mine, Timiskaming County, Que.*—(*Argentiferous galena*)

(*a*) Location:

The most important and interesting ore deposit of the east side of lake Timiskaming is the property known as the Wright mine, which comprises the western parts of lots 61, 62 and 63, range I, Duhamel township, shown on the maps as Blocks A and B. The ore body, which is exposed on the water-worn rock surface of the lake shore, was observed by the early French explorers, since the location is marked Ance à la Mine on a map of the lakes of Canada published in 1744, a print of which appears in Professor Miller's [19] report of 1905.[20]

(*b*) Geology:

In the vicinity of the mine, the rock is the breccia-conglomerate forming the basal member of the Huronian in this district, the pebbles or fragments of which are chiefly of granite, diabase or other eruptive rocks, embedded in a greenish, chloritic, slaty matrix, which owing to pressure appears to curve around or enfold the inclosed fragments.

The deposit occurs in a brecciated or shattered belt of the rock, composed of angular or subangular fragments, the interstices being filled by galena, with occasionally a small quantity of iron pyrites, together with more or less pink dolomite. Although this zone is about eighty feet in breadth and contains a varying quantity of galena throughout, only about six feet can be said to carry the mineral in workable quantity, and even this with considerable admixture of gangue and rocky matter. The rock immediately adjoining and inclosing the deposit has a decidedly porphyritic appearance, crystals and fragments of white feldspar and grains of transparent quartz being embedded in a fine-grained greenish matrix.[21].

(*c*) Character of the Ore:

A number of assays of the ore from this mine have been made, both in this department and by private assayers. The galena entirely free from gangue, is found to yield from 13 to 26 ounces of silver to the ton, with about 18 ounces as a mean value. It is also found to have a lead content of about 52 per cent., and usually yields traces of gold.[20]

Iron pyrites has been found intimately associated with the galena, and occasionally considerable quantities have been encountered in working the deposit. This is doubtless the source of the gold usually present in the ore.[21]

[16] Descriptive Catalogue of a Collection of the Economic Minerals of Canada: Paris International Exhibition, 1900, p. 104.
[17] Rep. Royal Com. Min. Res. Ont., 1890, p. 147.
[18] Geol. Sur. Can., Ann. Rep., Vol. X, N.S., 1897, p. 121 S.
[19] Ont. Bur. Mines, Vol. XIV, Pt. II, 1905; idem, Vol. XIX, Pt. II, 1913, p. 4.
[20] Geol. Sur. Can., No. 1064, 1910, pp. 38-40, M. E. Wilson.
[21] Geol. Sur. Can., Ann. Rep., Vol. X, N.S., 1897, pp. 147-149 i.

The values obtained in operation were greatly diminished, however, by the large amount of rock which had to be mined and the consequent crushing and concentrating which this involved. During the earlier part of its history the lack of transportation facilities was also a difficulty.[20]

(d) Origin of the Ore:

The origin of this irregular deposit is very obscure. The vein-matter has no doubt been deposited by replacement along a zone of fracture or brecciation in the Huronian, though the immediate cause of the brecciation in the conglomerate is not apparent. The occurrence of the ore in association with the porphyritic variation in the conglomerate is probably a mere coincidence, similar porphyritic rocks occurring quite frequently in the Huronian, as on Drunken island, and in the greywacké ridge which forms the southern boundary of the valley of the Little River.[20]

(*e*) Development:

Operations on this deposit were first begun in 1886, by Mr. C. V. Wright, of Ottawa, but no extensive work was carried on until 1890, when the property was acquired by the Mattawa Mining and Smelting Company. A very complete plant was installed and mining actively prosecuted until March, 1891, when work was suspended. From 1896 to 1902 the mine was operated in a small way, first by the Petroleum Oil Trust and later by the British Canadian Lead Company, both of these corporations representing English capital. Quite recently the property has changed hands, the present owners being the members of the La Rose Mining Company, of Cobalt. Active mining, however, has not been resumed. At the time of the suspension of work in 1902, a depth of 250 feet had been reached in the main shaft, while short drifts had been made at the 65, 100, 200 and 250 foot levels.[20]

(10) *Lead Hills Location, north shore of Lake Superior, Ont.—(Lead)*

(*a*) Location: The property is situated in the township of McTavish, at a distance of three or four miles west of the shore of Black bay.

(*b*) Ore Occurrence:

A rich vein of lead ore occurs in a pale red indurated marl. Prof. Chapman says of it: "The vein consists of a gangue of quartz, with enclosed portions of wall-rock, and some heavy spar, etc., carrying a very strong lode of intermixed copper pyrites and galena. The vein itself appears to average about ten feet in width; but at present it is to a great extent uncovered. The copper pyrites and galena, although scattered more or less throughout the vein, run principally in a solid lode, of at least four feet in width. The course of the vein is about N. 65° E.; and so far as this can be determined in the present undeveloped state of the vein, the dip, or underlie, is towards the southwest, at an angle of about 80°." In one sample he found 8.10, and in another 11.62 per cent. of copper. One of these samples also yielded 47.56 per cent. of lead. Another gave 38.35 per cent. of lead, nearly 1 ounce of silver and half an ounce of gold to the ton of lead.[22]

(11) *Lady Evelyn and Haycock Locations, Timiskaming District, Ont.—(Lead)*

(*a*) Location: The veins occur on the shores of the last stretch of Lady Evelyn lake, just before it empties into the Montreal river. The locality is about twenty-eight miles west-southwest of Haileybury.

(*b*) Description:

The western shore of this portion of the lake is composed of diabase that rises abruptly from the surface of the water and often forms steeply sloping or perpendicular cliffs. The contact between this rock and the slates is concealed for the most part by the lake, the eastern shore being altogether composed of a very distinctly banded greenish slate, which also rises into rather important elevations, having apparently been protected to a considerable extent from denudation by the proximity of the more unyielding diabase. The contact, for a short distance, runs inland along the western shore, leaving a comparatively narrow strip composed of the slates, which are seen to have been much shattered and broken up by the intrusion of the diabase. Some considerable masses of segregated quartz were here noticed filling irregular cavities and fissures produced during the eruption. Associated

[20] Geol. Sur. Can., No. 1064, 1910, pp. 38-40, M. E. Wilson.
[22] Geol. Sur. Can., Report of Progress, 1866-1869, pp. 358-359.

with the quartz is more or less calcite, and in this gangue were noticed galena, copper pyrites, iron pyrites and zinc blende. The banded slates on the eastern shore dip in an easterly direction at an angle of about 18°, and associated with and cutting these are similar segregated masses of "gash veins," in which galena is the prevailing constituent. The property on which these veins are situated is owned by Messrs. Klock and Haycock, and is locally known as the Haycock mine or location. A considerable amount of development work has been done, looking chiefly to testing the quality and extent of the ore bodies, but the inaccessibility of the locality would be a sufficient hindrance to any further operations, unless the deposit should prove of an exceptionally rich character. [Silver runs from 2 to 8.75 oz. per ton.] [23]

(12) *Bourke Deposits, Timiskaming District, Ont.—(Lead)*

(*a*) Location: Deposits of galena and zinc blende have been reported from the shores of Wolf and Twin lakes, in the vicinity of Bourke station on the Temiskaming and Northern Ontario railway.

(*b*) Description:

Narrow calcite veins, carrying small amounts of galena and zinc blende, have been found in the greenstone on the west shore of Wewegimok lake. To the south of Wolf lake there are several quartz-calcite veins carrying similar minerals. On claim H. R. 580, belonging to Mr. Dan Smith, of Sesekinika, one of these veins has been stripped or trenched for 200 feet. The vein, which is 14 inches wide at one place on the surface, carries a high proportion of galena and zinc blende. A shaft has been sunk 50 feet and several tons of lead-zinc ore have been piled up. The quartz has been deposited along the walls of the fissure, while the calcite, with most of the sulphides, has filled the centre.[24]

Samples of the ore were found to contain no silver.

(13) *Pie Island Deposits, Thunder Bay, Lake Superior, Ont.—(Zinc-lead)*

(*a*) Location: The veins occur on the western shore of this island, which lies across the mouth of Thunder bay.

(*b*) Geology:

The island consists of the usual argillaceous series of sedimentary beds traversed in a northeasterly and southwesterly direction by dikes of trap, the same rock capping the argillites in the table-topped hills. The developments were made on one of the northwest series of veins which occurs on the western shore of the island. The underground developments have been made in the vein where it cuts a trap dike, which intersects the argillites of the vicinity, or immediately adjacent to it.[25].

(*c*) Nature and Occurrence of the Ore Minerals:

The width of the vein is from three to four feet and is filled with a breccia of fragments of the country rock cemented together by crystallized quartz, which is mostly colourless but sometimes amethystine, and is accompanied by a little calcite which occurs mostly crystallized in scalenohedra in the vugs. The great feature of this vein, as shown by an inspection of the dumps, consists in the large amount of metallic minerals it carries. These are blende, galena and iron pyrites, mentioned here in the order of their preponderance, and all occurring for the most part well crystallized, especially in the case of the galena.

. . . This latter also occurs sometimes as thin seams in the joints of the argillite.

. . . An assay of such a piece showed it to carry neither gold nor silver.[25]

Some development work has also been done on a large vein on BB mining location, about a mile E.S.E. from the last-mentioned. It strikes in from the shore with a course N. 75° W. (magnetic) and dips to the north. It is about twelve feet thick, and is enclosed in the argillites of the district and intersects two trap dikes which cut through them. A shaft has been sunk on it. . . . In mineral contents it is very similar to the first mentioned, except that the quartz is accompanied by a good proportion of pink spar, probably dolomite. One assay made of some specimens selected as carrying some galena and a little blende, gave neither gold nor silver.[25].

[23] Geol. Sur. Can., Ann. Rep.. Vol. X, N.S., 1897, pp. 141-142 i.

[24] Ont. Bur. Mines, Vol. XXIII, Pt. II, p. 34.

[25] Report on Mines and Mining on Lake Superior: E. D. Ingall; Geol. Sur. Can.; 1888, pp. 53-54 H.

(14) *Deposits of the Sudbury Basin, Ont.*

From many localities within the interior sedimentary basin of the Sudbury area, Ontario, occurrences of galena and sphalerite have from time to time been reported. Pits and small shafts have been sunk on several of these, but the developments were not such as to encourage thorough explorations. The origin of these deposits is believed to be related to the norite intrusive.

The chief localities are the following:

Bowell township, location W.D. 252, east of the south end of Trout lake.

Within the Onaping tuff at points north of Fairbank lake, Fairbank township.

Creighton township, lot 10, concession VI, at Stobie falls, on Vermilion river.

Rayside township, lot 2, concession III, in the Trout Lake conglomerate.

Balfour township, lot 9, concession V.

Balfour township, lots 6 and 7, concession I.

Dr. A. P. Coleman makes the following notes on these deposits:

At several points the tuff has been found to contain small deposits of sulphides, especially zinc blende and galena, but never on such a scale as to be of economic importance. Such deposits are known at points to the north of Fairbank lake and along the same side of the basin towards the east, but the largest visited by us was a little east of the south end of Trout lake in Bowell township, where a location (W. D. 252, sometimes called Prue's mine) has been taken up, and a small shaft sunk showing quartz, with zinc blende, galena and a little copper pyrites. A dark grey, basic eruptive rock occurs beside the shaft and its eruption probably influenced the formation of the small ore body.[26]

At Stobie falls, on Vermilion river, in lot 10, concession VI of Creighton township, a considerable deposit of zinc blende with pyrite occurs in the Onwatin slate, and has been opened up on a small scale near the river bank.[26a]

Mr. R. R. Rose informs me that test pits have been sunk on a deposit of galena, sphalerite and pyrite with much quartz, on lot 9, concession V of Balfour township.[26b]

In the vicinity of Chelmsford, near Sudbury, are indications of zinc which may prove to be of some importance. These occurrences seem to have some connection with the graphitic slates, associated with which are also found the deposits of anthraxolite. . . . The location of this property is on lot 7, first concession of Balfour, four miles southwest of Chelmsford. . . . About 300 tons of ore had been extracted, said to show by assay 45 per cent. of zinc, 0.76 ounces of gold, and 9 ounces of silver per ton. The workings consisted of a development shaft. . . . . 98 feet deep.[27]

The mineralized zone, which is parallel to the bedding of the greywacké and slate, contains some fine-grained galena, pyrite, chalcopyrite and some sphalerite, all in small amounts. The gangue is made up of calcium carbonate, quartz and fragments of the wall-rock.

2.—Origin Probably Independent of Igneous After-action

LOW-TEMPERATURE DEPOSITS

The chief representatives of this group are a well-defined series of fissure veins, filled with a gangue of calcite, barite, fluorite and some quartz, and containing in several places considerable quantities of galena with some sphalerite, pyrite, chalcopyrite and marcasite. Some of the deposits resemble rather closely

[26] A. P. Coleman: The Sudbury Nickel Field: Ont. Bur. Mines, Vol. XIV, 1905, part III, p. 95.

[26a] A. P. Coleman: The Nickel Industry: Mines Branch, Dept. of Mines, Ottawa, 1913, p. 101.

[26b] Idem, pp. 101-102. [27] Ont. Bur. Mines, Vol. VIII, 1899, p. 33.

those of the previous group, especially where the quartz is plentiful, and where the silver values of the galena are above one ounce per ton. On the other hand, with the disappearance of the fluorite, quartz, barite and silver values in the veins, and a predominance of calcite with galena and sphalerite, the veins seem to resemble closely in composition the zinc and lead deposits of the Mississippi valley which are believed to have been formed by meteoric waters. All gradations exist between these two extremes.

The mineral composition of the veins is simple, and the constituents are generally coarse-grained. The veins are fillings in fault fissures, zones of brecciation, and joints. A full discussion of the origin and geological relations of this group will be taken up following the detailed descriptions of the chief deposits (Page 36).

A minor group of deposits, of little commercial value, also belongs to this division. In it occur deposits chiefly of zinc blende, which are both disseminated and in small gash veins in dolomites and limestones. They resemble closely certain phases of the Upper Mississippi Valley ore deposits. The mineral composition consists chiefly of calcite and dolomite, with varying quantities of sphalerite, marcasite and galena.

A.—Calcite-Barite-Fluorite-Galena Veins

(1) *Frontenac Lead Mine, Ont.*

(*a*) Location: This property, which comprises some 330 acres, is situated in Loughborough township, Frontenac county, Ontario, about 18 miles north of the city of Kingston. It consists of the south half of lot 16, part of lot 15 in the 9th concession, and the south half of lot 14 in the 10th concession. The arrangement of the lots is such that the property extends for a mile and a half along the course of the vein. The nearest station is Perth Road on the Canadian Northern railway about one mile from the mine.

(*b*) Railway facilities: The Toronto-Ottawa main line of the Canadian Northern railway crosses the south part of lot 16 within 200 feet of No. 1 shaft.

(*c*) Ownership: The property is owned by the North American Smelting Company, Limited, of Kingston, Ontario. The company also owns a lead smelter in the city of Kingston.

(*d*) History of operations: According to reports of the Geological Survey of Canada, a shaft was sunk on this deposit as early as 1866. Development work was continued in a desultory fashion until 1875, when the property was leased to an English company. About 2,000 tons of ore were mined at this period. In 1880 a lead smelter was constructed to treat the ores, but after two years of operation the mine and smelter were abandoned and remained so until 1911, when the property was taken over by the present owners. A new shaft was sunk to a depth of about 160 feet and a concentrator was built. About two years later, operations were discontinued, and at the time of writing the property is still inactive.

(*e*) Geology: The deposit occurs within the area of the pre-Cambrian shield and about two miles north of the overlapping edge of the Potsdam sandstone. The rocks occurring in the immediate neighbourhood of the mine are a series of interbedded siliceous and micaceous gneisses and crystalline limestones, striking

about N. 30° E. with a dip of 65° to 85° to the northwest. Pegmatite dikes intersect this series, probably originating from intrusive granite masses that occur a short distance to the north.

(*f*) Nature of the deposit: The deposit, which is a typical fissure filling, occurs as a calcite vein cutting almost at right angles across the rock formations. The course of the vein varies from N. 70° W. at the southeastern end of the property to about N. 30° W. at the northwestern end, with a rather uniform dip of about 75° to 80° to the northeast.

In all probability the vein is a filling of a fault fissure. Sufficient detailed work has not been done to determine accurately the displacement. Along the northeastern wall of the vein there occurs a well-marked clay gouge, which in places is about six feet thick. Horses of country rock are frequently seen surrounded by vein material. The somewhat smooth and in places slickensided walls, and the width of the vein, which averages about ten feet, combined with the previously mentioned features indicate rather strongly a considerable differential displacement of the walls. The structure and composition of the vein resemble closely those of another vein of the same general type, which is known to occupy a fault fissure. (See Galetta Lead Mine, page 21 below.) The vein cuts all the other rocks and is consequently the youngest formation in the district.

(*g*) Character and occurrence of the ore and gangue: The vein varies in thickness from about nine inches to twenty-two feet, with an average of about ten feet, as judged from its present development. The gangue is almost entirely calcite, with well-developed crustified structure. Along the north wall, as mentioned in the preceding paragraph, there is a persistent selvage of apparently argillaceous matter, and several horses of country rock. It is probable that the selvage consists of a very finely disintegrated portion of the country rock, rendered so at the time of the faulting. A similar situation seems to be developed at the Rossie lead mines in St. Lawrence county, New York, and it has been shown[28] that the selvage is merely finely ground country rock.

The metallic constituents of the vein are chiefly galena with smaller amounts of sphalerite and minor quantities of pyrite. It is interesting to note that the galena occurs in disseminated grains, and rather large crystals and clusters, arranged usually in certain horizons parallel to the crustification and close to the northeast wall. It is most abundant in the southeastern part of the vein where the latter intersects beds of crystalline limestone. Sphalerite is found chiefly in the northwestern part of the vein and occurs as fine-grained tabular masses, parallel to the crustification, and separated from each other by bands of calcite. The sphalerite is of the yellowish-brown variety not unlike that of the Upper Mississippi Valley deposits. Galena, also, is found in this part of the mine, but in its characteristic form of crystalline aggregates.

The galena is believed to occur in chutes, pitching northwesterly down the plane of the vein. In these chutes, the ore is in the form of disseminations of rather large crystals, and not massive, in accordance with the general significance of the word "chute." As the underground workings were full of water at the

[28] The Rossie Lead Veins: C. H. Smyth, Jr.: School of Mines Quarterly, Vol. XXIV, 1902-3, pp. 423 et seq.

time of the writer's examination, this occurrence could not be verified. However, certain parts of the vein are almost entirely barren of metallic minerals, while other portions show ten to fifteen per cent. of galena and sphalerite.

The older Geological Survey Reports on this property state that the ore assayed about five ounces of silver to the ton of galena. Recent silver determinations, however, have established beyond doubt the fact that the ore very seldom contains more than one and a quarter ounces of silver to the ton of galena. These averages accord more nearly with those of other ores of the same general type.

(*h*) Development: The extent and development of the vein are shown in the following sketch (Fig. 2). From the southeast to the northwest outcrops of the vein, the distance is about 5,000 feet.

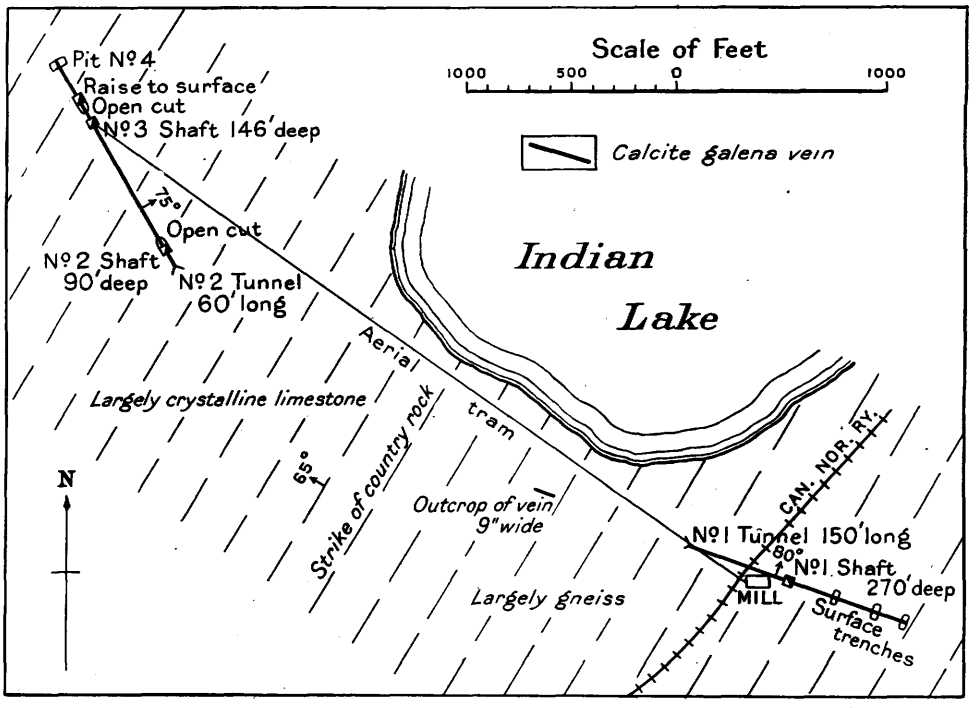

Fig. 2—Frontenac Lead Mine, Perth Road, Ont.

From the mouth of the tunnel at the eastern side of the swamp, the vein can be readily traced in a southeasterly direction by the tunnel itself, by shaft No. 1 with its drifts, and by surface trenches, for a distance of about 1,100 feet, as indicated on the sketch. A swamp covers the outcrop of the vein between tunnels No. 1 and No. 2, and the vein has not been located, except by a small outcrop of vein matter nine inches wide in a ridge of gneiss about a quarter of a mile northwest of No. 1 shaft. From No. 2 tunnel to No. 4 pit the vein can be followed at intervals by open cuts, shafts, drifts and trenches. Between No. 2 and No. 3 shafts a swamp intervenes, in which the vein has not been found.

Ore can be seen in place at the top of the shafts, in the open cuts, tunnels and trenches. The shafts vary in depth from 90 to 270 feet, and considerable drifting and stoping have been done at Nos. 1 and 3.

(*i*) Equipment: This consists of a recently-constructed concentrator, two power houses, compressors, and one well-constructed and equipped shaft at No. 3. Electric power may be brought to the property by the building of a short power line. There is an aerial tramway 3,900 feet long from No. 3 shaft to the mill, with a capacity of 20 tons per hour.

(*j*) Other Veins in the Neighbourhood:

On the eighteenth lot in the eighth concession a second vein runs parallel to the first, at a distance of about one hundred yards to the north of it. This second vein appears to be from three to six feet in width, and shows galena wherever it has been opened. It carries also a little barytes, which has not been found in the main vein. Smaller parallel lead-bearing veins have been discovered on the adjoining lots to the north.[38]

(2) *Chats Island Deposits, Ont.*

(A) Galetta or Kingdom Lead Mine:—

(*a*) Location: The chief deposit in this locality is the Galetta lead mine, owned by the James Robertson Company, Limited, of Montreal. It is located on Chats island in the Ottawa river, about five miles directly east of the town of Arnprior. The island is separated from the mainland by a narrow channel of the Ottawa river.

(*b*) Geology: The rocks in the vicinity of the mine consist of an interbedded series of crystalline limestones and biotite gneisses of pre-Cambrian age striking in a general northeast and southwest direction and dipping from 60° to 80° to the northwest. This series is intruded by igneous rocks of acidic and basic character. The lithological nature of the rocks was not accurately determined by the writer at the time of his visit. Unconformably overlying this complex, are the flat-lying limestones of early Paleozoic age.

The general area in this part of the Ottawa River basin is rather severely faulted[39] as shown on Map No. 25c. One of the faults occurs on this property, and Paleozoic limestones may be seen in normal fault contact with the pre-Cambrian complex.

(*c*) Character of the vein: The vein is a fissure-filling of the same type as the Frontenac lead mine vein. Its strike varies from N. 45° W. to due north (magnetic), and consequently it cuts nearly at right angles across the strike of the pre-Cambrian series. It usually has a steep dip towards the southwest.

The vein occupies a well-marked fault fissure. Near the northwest end, a small open cut shows on the northeast wall of the vein the steeply-dipping northeasterly striking gneisses of the pre-Cambrian and on the other the flat-lying Paleozoics, indicating a downthrow to the southwest. Horses of country rock occur throughout the vein, suggesting a fault breccia, while drag-folding is very evident at some places along the fracture.

For a distance of about 800 to 1,000 feet between the workings at the east and west ends, the vein had not been uncovered. There is a marked difference in the course of the vein at the two ends, but the fact of considerable differential movement having taken place prior to the filling of the fracture argues for the con-

[38] Geol. Sur. Can., Report of Progress, 1866-1869, page 165.
[39] E. M. Kindle and L. D. Burling: Geol. Sur. Can., Museum Bulletin No. 18, 1915.

tinuity of the fracture throughout a considerable distance, and suggests that the two portions of the vein will be found to unite. Particular notice should be taken of the fact that this vein is a filling of a very well-marked fault fissure. The amount of displacement was not estimated by the writer. In many places the vein seemed to be a filling of a fracture zone rather than of one well-marked fault fissure.

(*d*) Nature of the ore and gangue: The gangue is very largely calcite showing the banded character of a crustified vein, similar in all respects to that of the Frontenac lead mine. In some places in the vein, barite seems to be rather abundant.

The chief ore mineral is galena, which occurs in grains, clusters of crystals, and thin sheets, usually parallel to the banding of the gangue. The silver content of the galena is rarely over one ounce per ton. Sphalerite and pyrite occur in minor quantities.

On account of the fact that it was through a special courtesy on the part of the President of the company that the writer was permitted to examine the mine, it is deemed inadvisable to describe fully the dimensions of the developed vein, and the grade of ore. At the stage of development existing at the mine in February, 1915, the property was without doubt the most promising lead prospect in Ontario.

(*e*) Operation: Development work, both underground and surface, has been carried on by the company for over a year, and at the time of writing a new concentrating mill had just been set in operation.

(B) Campbell's Prospect:—

(*a*) Location: The property is situated near the northwestern end of Chats island, and is apparently a continuation of the Galetta vein just described. The greater part of the deposit occurs in a shallow bay of the Ottawa river, between the high and low water marks. When the water is low, usually in August, a small island appears in the centre of the bay, and on this there is a shallow shaft and some pits located on the vein. During the larger part of the year, however, the river covers the outcrop to a depth of four to five feet. Pickets standing in the pits show the location and course of the vein at high water.

The property is owned by Mr. Jos. Campbell, of Arnprior.

(*b*) Geology: Both the lower Paleozoic sediments and the interbedded pre-Cambrian series of gneisses and crystalline limestones are found at this locality. There is considerable evidence of brecciation at the contact of the two series, suggesting fault relations.

(*c*) Character of the vein: The vein is of the crustification type and is composed of calcite with some barite. In width it varies from a few inches to three feet, and in this respect it is very similar to the pinch-and-swell character of most of the veins of this group. The vein has not been traced continuously at any one point for more than seventy-five feet, although the total length between the end pickets is about 500 feet.

(*d*) Nature of the ore: The ore mineral is galena, which is said to occur abundantly at certain places along the vein. It occurs in the disseminated form, but clusters of distorted cubes, commonly known as "cog lead", of considerable size have been taken out. Very little sphalerite and pyrite were seen in the vein material. The silver content of the ore is not known, but it is unlikely that it is more than about one ounce to the ton of galena.

(*e*) Operation: Very little work has been done on the property, on account of the fact that the vein is rather inaccessible throughout a large part of the year. No operations of any kind are being carried on at present.

(3) *Hollandia Lead Mine, Ont.*

(*a*) Location: This property is located on lot A, concession VI, Madoc township, in the county of Hastings, Ontario. It is about two miles northeast of Bannockburn on the Central Ontario railway, which is the nearest railway station.

(*b*) Geology: The deposit occurs within the area of the pre-Cambrian shield of southeastern Ontario. The rocks consist of crystalline limestone, micaceous quartzite, and quartzose schists, in a highly-inclined interbedded series striking about N. 45° E.

(*c*) Character of the deposit: The ore occurs in a calcite vein which cuts almost at right angles across the rock formations and strikes about N. 54° W. Although outcrops have been found over a linear extent of about a mile, the vein does not appear to be continuous. It is rather a series of pinches and swells, and at certain points successive northwesterly outcrops seem to be slightly offset towards the southwest. In all probability the vein occupies a zone of dislocation very similar to that observed at the Galetta lead mine, for example. The walls of the vein are smooth and slickensided, and horses of country rock are not uncommon within the vein. The amount and direction of displacement were not determined at the time of examination, the workings being old and filled with water and surface debris. In certain places the vein attains a width of ten feet and usually exhibits well-marked crustification.

(*d*) Nature and occurrence of the ore: The ore consists chiefly of galena, with minor amounts of sphalerite. Silver values are very low, as would be expected. Pyrite occurs in the vein, but it is not abundant. The gangue minerals are calcite and barite, the latter being in small amount.

The galena occurs both as disseminated crystalline groups throughout the gangue, and as thin tabular masses parallel to the banding of the vein. Frequently it appears to be segregated towards the middle of the vein, which is usually very heavily mineralized. Sphalerite may be seen here and there in disseminated grains in a plaster of the gangue minerals still clinging to the walls.

The grade of the material as it was broken during previous operations must have exceeded ten per cent. in galena. A considerable dump of vein material now lies beside the mill shaft, and a conservative estimate would place its galena content at eight per cent. Very little of either barren rock or gangue occurs in the

dumps, and some small shipments of dressed galena have already been sent to the smelters. It was stated to the writer that the dump at the mill shaft represents what was left of the "mine run" after the coarse galena was cobbed and shipped.

(*e*) Development: The mine is an old one and has been worked intermittently for several years. At the time of writing it had been closed down for about eight years, and the workings were full of water. These consisted of three shafts, having respective depths of 150, 100 and 70 feet, with about 600 feet of drifting. A small power and concentrating plant had been built at the time of the last operations.

At the southeastern end of the property the vein has been opened up almost continuously by shafts, drifts and surface stripping for a length of 250 feet. Towards the northwest, trenches dug at intervals of several hundred yards along the same general strike, showed in places small amounts of vein material and some galena. It is not known whether these are extensions of the main vein or parts of parallel ones.

The property seemed to be well worthy of systematic exploration and development.

(4) *Katherine Lead and Zinc Mine, Ont.*

(*a*) Location: The Katherine mine is situated on lot 6, concession XI, Lake township, Hastings county, Ontario. It is about three miles west of Millbridge on the Central Ontario railway.

(*b*) Geology and occurrence of the ore: Owing to the fact that exposures in the vicinity of the mine are poor, and that the workings were full of water at the time of the writer's examination, the geology and character of the vein could not be studied. The following quotation is from a report on the district by Drs. Adams and Barlow.

> The vein and associated rocks are very similar to the occurrence worked at the Hollandia mine, with the exception that a considerable proportion of zinc blende accompanies the galena. A shaft was sunk 125 feet deep, and at a depth of 100 feet a level was driven north 100 feet and some stoping done. Half a mile south of this shaft another was sunk to a depth of 18 feet. Some prospecting was done by means of a drill, and a hole 292 feet deep was made.[21]

The following note by the Ontario Mining Inspector, C. De Kalb, is interesting:

> The vein carries argentiferous galena and zinc blende in calcite, the average of the ore showing ten ounces of silver. It lies wholly between walls of diorite, with a width varying from one to four feet, and a known longitudinal extension of half a mile. . . . Half a mile south of the main shaft is the south shaft. . . . The vein here is less highly mineralized, having, however, a width of nine feet, with six ore-bearing streaks, containing galena, but no zinc.[22].

The reported content of silver is noteworthy, especially if reliable, since it is so much higher than that of similar ores in the series of calcite veins now under discussion.

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[21] Adams and Barlow: "Geology of the Haliburton and Bancroft Areas, Ontario": Geol. Sur. Can., Memoir 6, 1910, p. 349.

[22] Ont. Bur. Mines, Vol. X, 1901, p. 130.

(5) *Bedford Lead Prospects, Ont.*

Several calcite-barite veins containing galena occur in the township of Bedford, county of Frontenac, Ontario. These all have a more or less northwest-southeast strike, and occur at intervals close to the road from Fermoy to Sangster. Only the best-developed vein was examined in any detail by the writer, and the following description of several of the occurrences is from reports of the Geological Survey of Canada:

Several veins containing galena are met with cutting the Laurentian limestone in the township of Bedford. One of them, on the twenty-first lot of the eighth range, has a direction about east and west, with an underlie to the north < 80°. It is four feet wide, and consists chiefly of calcspar, through which galena is disseminated in crystals or in seams, sometimes an inch or two in thickness. A shaft was formerly sunk here to a depth of twenty-five feet. Two other veins similar in character are met with near the line between the eighteenth and nineteenth lots of the same range, the one running N. 20° W., and the other N. 37° W. A little to the west of these, and on the nineteenth lot of the seventh range, on the property of Mr. Weston Hunt of Quebec, are five nearly parallel lodes, running northwest, and included in a breadth of a quarter of a mile. They traverse crystalline limestone, and include galena in a mixture of calcspar and heavy spar. A specimen from one of them shows a breadth, across the vein, of five inches of solid galena. About a mile to the eastward of these lodes, there are others on land belonging to the proprietor of the last. Shallow trial shafts were, many years ago, sunk upon these, but the amount of lead ore obtained from them is not known. On lot thirteen of the fifth range of Bedford, Messrs. Foley & Co., of Montreal, have sunk a trial shaft to a depth of sixteen feet, on a lode of six inches, the gangue of which is heavy spar. The lode traverses the crystalline limestone, and enters the gneiss, in both of which rocks it holds good masses of galena.[23]

The following description of the most important vein of the group is from the writer's notes, and is based on recent examinations.

(*a*) Location: This deposit is located on lots 16, 17 and 18 of the sixth concession of Bedford. The nearest railway facilities are at Westport, on the Brockville and Westport railway, a distance of about ten miles from the property.

(*b*) Geology: An interbedded series of white crystalline limestones, gneisses and schists, with intrusive granites, striking about N. 60° E., magnetic, and dipping about vertically, constitutes the chief country rocks of the district. The series is of pre-Cambrian age.

(*c*) Nature of the vein: Structurally the vein resembles that at the Hollandia, Frontenac and Galetta mines. It strikes N. 75° W., magnetic, cutting sharply across all the formations, and constitutes the youngest rock of the immediate area. It varies in width from a few inches to four feet, and is of the pinch-and-swell type. The walls of the vein are smooth and clean-cut, and horses of country rock are occasionally seen apparently surrounded by vein matter. In very many places the vein anastomoses, forming a series of small veins separated from each other by barren rock. The deposit appears to be a filling of a brecciated zone which was produced, probably, by faulting.

(*d*) Character and occurrence of the ore and gangue: The chief gangue minerals in the vein are barite and calcite. The vein material is distinctly banded, but ordinarily the calcite and barite occur together within the individual bands.

[23] Geology of Canada, 1863, pp. 687-688.

In certain parts of the vein, calcite is the predominant mineral, while in other portions barite is the more abundant.

The metallic mineral is almost entirely galena. No zinc blende nor pyrite was seen. The galena occurs disseminated through the gangue, but all parts of the vein are by no means equally rich. In places it seems to be entirely barren of the ore mineral. In other portions it is exceptionally rich. In the bottom of one pit the galena was stated to be so abundant that an examining engineer reported that it was equivalent in amount to a solid sheet 24 inches thick. In other pits, full of water at the time of the writer's examination, it was stated that there was sufficient galena to make solid sheets eight and ten inches thick. The galena occurs in crystal masses from the size of buckshot to bodies so large that they could not be lifted out of the pits without being broken. Wherever the galena occurs abundantly, the barite seems to be quite massive rather than banded.

(*e*) Development: The vein is opened up by nine pits along the same strike, extending over a distance of about 1,600 feet. They all show certain amounts of galena. Other pits are located about 800 feet further northwest, but these show only small stringers of barite with no galena.

The main pit, which is 26 feet deep, was full of water at the time of examination. The vein at the bottom of this pit was reported to be six feet wide, and to consist of rich galena ore in a gangue of calcite. At the top of this pit the vein branches into three or four narrow veins, all containing some galena. At no place on the surface was the vein observed to be more than twenty inches wide. For the amount of work already performed on the deposit, the results are encouraging, and further systematic exploration would in all probability prove an ore body of considerable extent and grade.

(6) *Union Creek Lead Mine, Ont.*

The following description is given in a report of the Geological Survey of Canada:

> A deposit of lead ore has been opened on lot 20 range A, of Galway township, Peterborough county, Ontario. A shaft with lateral drifts has been sunk to a depth of about 100 feet, but this at the time of my visit was filled with water. Near it, however, a short tunnel is driven in the vein from a hill side. In this the vein is seen to vary somewhat in width, but to be fourteen inches wide at its widest part. The veinstone is barite with some calcite, carrying in the tunnel a few grains of iron pyrite, zinc blende and galena. A considerable amount of galena has been taken from the shaft where the vein is said to be somewhat wider and contains the galena in pockets. I am informed that about thirty kegs of galena have been shipped. A number of specimens of the galena and barite as well as a few of calcite and zinc blende now lie about the mouth of the shaft. . . . The galena was found to contain neither gold nor silver. The vein cuts gneiss which is interstratified with crystalline limestone.[34]

The deposit was worked in 1911, and some ore was concentrated in the mill.

(7) *Crown King Lead Prospect, Ont.*

(*a*) Location: This property is located on lot 1, concession VII of Somerville township, Victoria county, Ontario.

[34] Geol. Sur. Can., Ann. Rep., N.S. Vol. VI, pp. 14-15 J.

(*b*) Geology: The rocks are similar to those described for the Union Creek area above. They consist of interstratified crystalline limestone and highly micaceous gneiss in vertical position, and striking northeast and southwest.

(*c*) Character of the veins: On the surface there seem to be three parallel veins, cutting across the rock formations and striking N. 50° W., magnetic. They vary in width up to four inches, and consist chiefly of barite banded parallel to the walls. They are probably the continuation of the mineralized zone of the neighbouring Union Creek property.

(*d*) Nature of the ore: The ore mineral is almost entirely galena, with which one of the veins is richly mineralized. The galena is more in the massive and less in the disseminated form than at the other properties previously described.

(*e*) Development: The veins are stripped at intervals for a distance of about 200 feet. There are three small pits within this distance, the main one being 17½ feet deep, but it was full of water at the time of examination.

(8) *Ramsay Lead Mine, Ont.*

On the third lot of the sixth range of Ramsay [township, county of Lanark, Ontario], a mine has been opened upon a vein holding galena, and cutting a grey dolomite which belongs to the Calciferous formation. The beds of this are nearly horizontal; and they repose conformably upon the sandstone of the Potsdam formation, the outcrop of which is seen at a distance of about a mile from the mine, where it reposes upon the upturned limestone and gneiss of the Laurentian series. The lode has a bearing of from N. 50° W. to N. 55° W., with an underlie to the northeast of about a foot in a fathom; and it has a breadth of from two and a half to five feet, the ore-bearing part varying from eight to twenty-four inches. The galena occurs in a gangue of calcspar, with small portions of iron pyrites, copper pyrites and blende. A shaft of thirty-seven feet was sunk upon this vein, and about seventy-five fathoms in the plane of it having been extracted, twenty-six tons of ore, yielding eighty per cent. of lead, were obtained. Some portions of the lode were nearly destitute of ore, while in other parts its amount was estimated at nearly two tons to the fathom.

This trial was made in 1858, when a smelting furnace was built, and a ten horse-power engine was erected for the purposes of a blast, and to remove the water from the mine. The influx of water was however, so considerable, that this was found insufficient, and the mine was for a time abandoned. More recently, however, a new engine of fifty horse power has been erected. About 105 fathoms southeastward from the main shaft, a counter-lode joins the main one, at an angle of about 20°; its course being nearly N. N. E. and S. S. W. At the junction of the two lodes, a shaft has been sunk in sandstone to a depth of twenty-one feet; and in the excavation, in which the united lodes attain a breadth of ten feet, there were obtained about ten tons of twenty-per-cent. ore. Other lodes holding lead ores, and nearly parallel with the ones described, have since been noticed in the vicinity.[35]

The lode is reported to outcrop to the southeast, on the shores of the Mississippi river at Carleton Place, one mile distant. An outcrop has also been reported several hundred feet to the northwest.

It is interesting to note that the veins in this area traverse the Ordovician limestone, and are known to be at least post-early-Ordovician in age. The resemblance of the other veins of this group, which are found entirely within the pre-Cambrian, to the Ramsay veins adds considerable interest to the question of their time relations.

[35] Geology of Canada, 1863, pages 688-689.

(9) *Lansdowne Lead Veins, Ont.*

Veins similar to those just described are found in Lansdowne township, county of Leeds, Ontario.

One of these, on the second lot of the eighth range, has been traced for a quarter of a mile, running nearly N.W. and S.E., and has an average breadth of two feet. Through the gangue, which is of calcspar and heavy spar, galena is irregularly distributed in crystals and small masses; and it is also found disseminated in the crystalline limestone which forms the walls of the veins. Trial shafts were at one time sunk here; but the mine was abandoned. Another lode running N. 65° W., was subsequently found on the third lot of the same range. It traverses crystalline limestone, and has a breadth of from six to twelve inches. Through the gangue, which is calcspar, galena is found in masses sometimes five or six inches in diameter. A trial shaft of fifty feet, which was sunk upon this lode in 1854, on the land of Mr. Buel, is said to have yielded sufficient ore to pay the expenses of sinking. A branch lode diverges from the main one near the shaft; and in the same neighbourhood there occur four other lead-bearing lodes parallel with the main, the whole being included in a breadth of about 1,000 feet. These run obliquely across the lots, and thus intersect the lands of several proprietors. On the fourth lot of the eighth range, Messrs. Foley & Co. have sunk a small shaft upon one of the lodes.[36]

(10) *Tudor Group of Lead Veins, Ont.*

This group of veins, although of minor importance commercially, is very interesting both on account of structural and lithological character and location with respect to previously discussed deposits. (See Map. No. 25c.) Since the deposits were not examined by the writer, the following descriptions from the literature are given in full. The veins occur in Tudor township, county of Hastings, Ontario.

Most of the localities known as affording galena have been noticed in Mr. Macfarlane's report for 1866, but during my explorations in Tudor, having visited all the lead-bearing lodes, openings were found to have been made in some, of which the localities only had been previously indicated, and one or two were in a better condition for inspection than at the time of Mr. Macfarlane's visit.

One of these on the twenty-eighth lot of range B, in Tudor, is a vertical vein running N. 70° W., the strata of calc-schist dipping 270° < 76°. At the time of Mr. Macfarlane's visit, a shaft which had been sunk on it to a depth of thirty-seven feet, was half full of water, preventing him from doing more than to state the information he had received from others. In 1867, I found that the lode, of which the veinstone is barytes and calcspar had yielded on the average three-quarters of an inch of galena; but the bottom of the shaft showed no more than half an inch of barytes, without galena. I was informed by Mr. W. Kesterman, of Belleville, then superintending the mine, that there had been extracted from the vein about six tons of galena, four and a quarter tons of which were sent to New York for sale, after being simply crushed and found to yield 66 per cent. of lead.

On thirty-first and thirty-second lots of the range east of the Hastings road, in Tudor, a lead-bearing vein runs in a vertical attitude N. 75° W., cutting the grey calc-schists with strike N.N.E.

In 1867 it had been traced in the direction given, across both the lots mentioned, with very good surface indications, and was known as the Murphy mine. The Hastings Lead Mining Company subsequently sunk a shaft on it, which, I understand, had been carried down to a depth of 125 feet, but the result being unsatisfactory, the work was abandoned.

On lots 28 and 29, concession XIV of Tudor, there is a vein of red and white heavy spar holding galena, and cutting the grey calc-schists. Its bearing is N. 5° E., and it stands in a vertical attitude, while the enclosing rock, also vertical, strikes almost due north and south. It was discovered some eight years ago, and was first opened in 1859. In 1867 the mine was leased by Messrs. Lombard & Co., of Boston, who were working it at the time of my exploration in Tudor, and I had an opportunity of examining the shaft when free from water. The walls were regular and well defined, the width between them being in some parts from eighteen inches to two feet, and the ore appeared in scattered and irregular bunches in the gangue. When first opened, this vein yielded some large masses of ore, but,

[36] Geology of Canada, 1863, p. 688.

as in a previously mentioned instance, they greatly diminished, descending, and at the bottom of the shaft, which was twenty-five feet deep, there was scarcely any ore. In 1868, at the depth of forty-two feet, the mine was abandoned. It may be remarked that many of these veins in Tudor, yielding considerable bunches of ore near the surface, show little more than traces of galena at the depth of a few feet. Of twenty-five localities in Tudor, in which galena was discovered and partially worked, only one, the Murphy mine, continued to be worked in 1868.[37]

(11) *Lake Group of Lead Veins, Ont.*

This group is of the same general type as the Tudor group, and is of the same degree of importance. They are located in Lake township, county of Hastings Ontario.

Description:

The west half of lot 10, concession XI of Lake, is another of the localities mentioned by Mr. Macfarlane. On this lot, which was some time since bought by Messrs. Gillum and Kesterman, of Belleville, occurs the Donahue vein, striking N. 50° W., and standing in a vertical attitude. Little, however, has here been done, and although the lode has a width in some parts of from twenty to twenty-four inches, bounded by regular walls of grey calc-schist, the galena occurs only in scattered and irregular patches, and in considerable quantity.

On lot 8, concession XI of Lake (or possibly in concession X) a vertical vein, holding galena in a gangue of heavy spar, runs through a calc-schist in the direction of N. 45-50° W. The lode varies in thickness from ten to eighteen inches, and is bounded by well-defined walls. Little had been done on this lot up to 1867, but in the short distance then uncovered, I saw extracted some masses of ore, at a depth of three feet from the surface, which weighed from fifteen to forty pounds, and I was informed that when first discovered much larger masses had been taken from the vein. The lode is supposed to be on the property of Mr. Wm. Sweeny, of Tudor, but in consequence of the defective manner in which the township has been surveyed there at present exists a dispute as to the ownership of the lot.[38]

(12) *Methuen Lead Vein, Ont.*

(*a*) Location: Township of Methuen, Peterborough county, Ontario.

(*b*) Description:

There occurs a northwest and southeast lode near the southeast corner of Methuen, where, in 1868, a shaft was being sunk by Messrs. Parker and Baker. On this lode two or more shafts have been opened on the eastern edge of the second lot of the first range, close to the boundary line of Lake. The lode cuts grey vertical calc-schist, striking N. 20° E., and is composed of calcspar and heavy spar, the former being of a rose or flesh-red colour, in which there is a good show of galena. The average width of the lode is about eighteen inches, and it has been traced in a southeasterly direction for nearly three miles into Marmora.[39]

(13) *Storrington Lead Vein, Ont.*

In the township of Storrington [county of Frontenac, Ontario], near the shore of Dog lake, about two miles from the village of Battersea, another well-defined lead vein has been uncovered, and would appear to be in the strike of one of the lodes belonging to the Frontenac Company.[40]

[37] Geol. Sur. Can., Report of Progress, 1866-1869, pages 162-163.

[38] Geol. Sur. Can., Report of Progress, 1866-1869, p. 163. *Note*: These descriptions by Mr. Vennor are quoted in Museum Bulletin No. 6, Geol. Sur. Can., 1910, pp. 346-349.

[39] Geol. Sur. Can., Report of Progress, 1866-1869, pp. 163-164.

[40] Geol. Sur. Can., Report of Progress, 1870-71, p. 314.

(14) Other localities in which similar calcite-barite-galena veins are found in Ontario[41] are:

Lake	township,	concession	XI,	lot 11.
Limerick	"	"	II,	" 27-29.
Tudor	"	"	III,	" 32.
	"	"	V,	" 12.
	"	"	VI,	" 11.
	"	"	VII,	" 10.
	"	"	XIX,	" 26, 27, 28.
	"	"	A,	" 21-28.
	"	"	B,	" 5, 6.
	"	"	B,	" 27, 28.

(15) *Hull Lead Veins, Que.*

(*a*) General location: township of Hull, county of Ottawa, Quebec.

A beautiful vein of this mineral occurs on the west half of the seventh lot in the tenth concession of the township of Hull, four miles from the Gatineau river. It varies in width from two to three and a half feet, and was traced for upwards of 100 yards in a N.N.E. direction. The adjacent rock is a highly crystalline white limestone striking N. 22° 30′ E., and dipping to the southeastward at a steep angle. The barytes is of an opaque white colour, and is associated with sea-green fluorspar, which occurs chiefly towards the edges of the vein.[42]

(*b*) Opaque white barytes was observed in the south half of the seventh lot of the tenth range of Hull, on the property of Mr. Morris Foley. It occurs in a vein from four to six inches wide running N. 48° W. . . . About eighty paces north of this position there are blocks of barytes, some of which appeared to be about a foot wide, associated with sea-green fluorspar, and very probably derived from some other vein near the spot. No galena was observed to be associated with the barytes in this lot.[43]

In these two deposits, special attention is called to the presence of fluorspar in association with galena, calcite and barite in veins otherwise almost identical in structure and composition with those previously discussed in this group. The significance of the fluorspar in these and other deposits is taken up at the end of this section, following the descriptions of the various prospects (page 39).

(16) *Buckingham Lead Veins, Que.*

(*a*) General location: Buckingham township, Labelle county, Quebec.

(*b*) Description:

In some of the exposures of the limestone (crystalline) in Buckingham, it is intersected by veins of opaque white sulphate or barytes holding galena. One of these veins occurs on the 21st lot of the 4th range of the township, belonging to Mr. James B. Gorman. According to the report of Mr. J. Lowe, in the vein of barite, which is from six to fourteen inches wide, there are two strings or bands of galena. Of these, where exposed, one is an inch, and the other an inch and a half thick. . . . The course of the vein appears to be about N. 50° W., and its underlie N. 40° E., $<$ 72°. Thirty paces to the westward from the opening on this lode there is another vein of the same character. It also is six inches wide, and consists of barytes, but the quantity of galena is less. The course of the vein, as indicated by an exposure of sixty feet is S. 53° E. On the line between the 20th and 21st lots of the same range, there is another vein of barytes, in which, however, no galena was visible at the spot where it was exposed.[44]

[41] Geol. Sur. Can., Memoir No. 6, 1910, p. 350.

[42] Descriptive Catalogue of a Collection of the Economic Minerals of Canada, and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876.

[43] Geol. Sur. Can., Report of Progress, 1866-1869, p. 20.

[44] Geol. Sur. Can., Report of Progress, 1863-1866, p. 19.

(17) *Indian Cove Lead Veins, Que.*

(*a*) Location: east end of Gaspe peninsula, Quebec.

(*b*) Description:

The other locality of galena is in Indian Cove. Here is a downthrow to the southeastward, of at least thirty fathoms, by which the higher sandstone is brought opposite to the limestone. Between these walls, there is a lode about twelve feet wide, composed of the ruins of the two rocks cemented together by calcareous spar, and including numerous small veins of the same mineral, with crystals of galena. The principal one of these veins is about two inches wide in the thickest part; it has an underlie N. 74° W. < 55°; but the general course of the whole lode, in which the small veins occur, is about N. 18° E., and the underlie appears to be westward. The dislocation in this place points to a transverse valley or depression in the hills behind, which appears to run across to the opposite side of the promontory, in a course nearly N.E. In a dislocation on the northeast side of the promontory, which is supposed to correspond with the fault, and where a continuation of the lodes might be expected, no ore has yet been observed.

Transverse dislocations are of common occurrence in this vicinity. One of them, in a recess about a quarter of a mile above Indian Cove, is filled with white calcareous spar, which has a thickness of nine feet in one part, and one foot in another. The underlie of the vein is S. 65° E. < 76°, while the dip of the strata at the spot is S. 55° W. < 22°. On the north side of the promonotory, seven dislocations, in the space of about a mile and a half, may be seen at one view, from a convenient distance out on the water. The displacements in six of these compensate one another; and the slope or underlie of the faults, in every instance, is in the direction of the downthrow.

Greenstone dikes, intersecting both the limestones and the sandstones, are seen in several places.[45]

It is interesting to note the presence of greenstone dikes cutting the formations in which the galena deposits occur. This situation resembles somewhat that in southern Illinois, where it is possible that a genetic relation exists between the fluorite-sphalerite veins and a series of basic dikes. (See page 40.)

(18) *Little Gaspe Cove Lead Veins, Que.*

(*a*) Location: east end of Gaspe peninsula, Quebec.

(*b*) Description:

One of these localities is in the bight of Little Gaspe cove, where the limestone is washed by the waters of the bay. Here are several fissures, holding these two minerals, and having a direction of N. 55° E., with an underlie to the northward. Near to these veins is a dislocation, with a downthrow on the northwest side, by which the limestone is brought against the higher sandstones. It is probable that the mineral veins have some connection with this dislocation.[46]

The lode occurs in a mass of stratified limestone, which dips about S.W. 24°; and rises northward into a hill 700 feet in height, which constitutes Gaspe promontory. It has a breadth of about eighteen inches, and is composed of calcspar holding masses of galena, together with small portions of blende and copper ore. A trial shaft was sunk here to the depth of twenty feet upon the main vein, from which, and from several smaller parallel veins in the vicinity, about twenty tons of sixty-per-cent. ore were recently obtained. Besides the two localities already mentioned, galena has been observed in veins in several other localities in the limestones on the south side of Gaspe promonotory; and also on the north side, in a vein which may perhaps be a continuation of that of Little Gaspe cove.[47]

[45] Geology of Canada, 1863, pp. 400-401. [46] Idem, pp. 400-401. [47] Idem, p. 691.

(19) *Baie-St. Paul Lead Veins, Que.*

(*a*) Location: forty miles below Cap Tourmente, St. Lawrence river, Quebec.

(*b*) Description:

Here mineral veins occur, holding small quantities of galena. The gangue in which the ore is distributed is composed of calcspar, mingled with apple-green fluorspar. The veins on the south side of the limestone are smaller than those on the north, but they are all probably connected with one great line of disturbance. On the north side, there are two parallel veins in the space of six feet, one of them being three feet wide, including a fragment of gneiss which occupies half the breadth.[48]

(20) *Petite-Nation River Lead Veins, Que.*

(*a*) Location: north shore of the Ottawa river, a few miles east of Ottawa.

(*b*) Description:

Among others a vein of six or eight inches is said to exist upon the Petite-Nation river, on the seigniory of the Hon. L. J. Papineau. Galena has also been brought from the Gatineau and the Black river; in the former case, associated with purple fluorspar.[49]

Note: The most interesting feature in connection with this and the Baie-St. Paul deposits is not the galena content of the veins, but the fact of the association of fluorspar with the calcite, in veins otherwise resembling the calcite-barite veins previously discussed.

(21) *Rossie Lead Veins, New York State.*

(*a*) Location: These are located in St. Lawrence county, New York state, near the town of Rossie. Descriptions of the deposits are given here, because in their general characters the veins closely resemble those of the Frontenac, Galetta, Hollandia and other properties in Ontario. Furthermore, their location and strike suggest that they may be the southeastward continuation of the Bedford and Lansdowne or Frontenac veins.

(*b*) Description: The country rocks are interbedded gneisses and crystalline limestones of pre-Cambrian age which strike northeast and southwest. Considerable mining had been done on these veins in the early days, but for the last forty years at least they have not been worked. Fluorspar had also been reported from these deposits, although it is not mentioned in the following description.

The veins cut across the foliation of the gneisses at a high angle, approach parallelism with one another, and have a strike of about N. 80° W. The Coal Hill vein is the largest of the group.

The vein varies from two to six feet in width, is nearly vertical, and sharply defined. As is well known, the gangue is coarsely crystalline calcite, carrying galena, with a little pyrite, and small amounts of sphalerite and chalcopyrite.

. . . The galena, though quite bunchy and irregular, is on the whole more abundant towards the middle of the vein.

Some parts of the vein, particularly along the margins, contain abundant inclusions of the wall rock, forming a breccia cemented by the veinstuff. The fragments vary greatly in size, and are sometimes angular, while in other cases they are rounded and have clearly

[48] Geology of Canada, 1863, pp. 161-162. [49] Idem, p. 690.

suffered much loss by attrition or solution, or both. . . . To the unaided eye there is indication of much alteration, but closer examination, while showing alteration beyond doubt, tends toward the view that it has been very limited in amount. Under the microscope, fragments that, to the unaided eye, appear thoroughly altered, show a large amount of material which, beyond crushing, shows no change. Perfectly fresh, angular or rounded fragments of the various minerals lie in calcite and galena, with no trace of corrosion or alteration; and such fragments are decidedly in the majority.

Whether or no this fracturing was attended by any large vertical displacement is not shown, although the fissures are evidently due to faulting. The nature of the rocks is such that faults of some magnitude might give no measure of the amount of throw.

In view of the character of the minerals, both gangue and ores, their source is, perhaps, more apt to be found in the crystalline limestones which are frequent in the vicinity, and outcrop only a few rods east of the ridge in which the veins occur.[50]

(22) *Redwood Lead Vein, New York State.*

(*a*) Location: This vein is located in Jefferson county, New York state, near the town of Redwood. It is described here, because of its resemblance to the Ontario and Quebec deposits of this group, and because of its position with respect to the deposits in Lansdowne, Storrington, Bedford and Loughborough townships. In this connection, also, it is interesting to note that the Redwood vein cuts the Potsdam sandstone.

(*b*) Description:

About a mile north of Redwood, Jefferson county, the R. W. & O. railroad makes a deep cut through the Potsdam sandstone, affording a section some five or six hundred feet long. Throughout the section the sandstone is much crushed, but the strata remain nearly horizontal, and the faulting doubtless present is not sufficient to bring in any other horizon.

At one point in the section there is a fissure, from four to six feet wide, filled with calcite carrying galena, pyrite and sphalerite. Several smaller veins occur, there being, indeed, an irregular crushed zone about forty feet wide, within which the veinstuff and sandstone fragments form a breccia.[51]

(23) *Smithfield Mine, Nova Scotia—(Lead)*

A visit was made during the summer to this property, which is now held by Messrs. C. F. Fraser, Howard Clark, *et al*, of Halifax. Although the shafts were full of water and the property idle for some time there was every evidence of considerable work having been done. I was informed that the underground work consisted of two shafts thirty and sixty feet deep. From the bottom of the thirty-foot shaft a cross-cut has been run from the footwall a distance of thirty-three feet to the south, traversing good ore throughout, but falling short of reaching the hanging wall. From the easterly or sixty-foot shaft two drifts had been run on the vein in either direction to a distance of thirty feet each.

The vein with an estimated thickness of thirty feet strikes approximately east and west and dips at an angle of 80° or 85° to the south, the country rock consisting of Carboniferous limestone striking N. 75° W. The ore consists of fine and coarse-grained argentiferous galena associated with iron pyrites, calcite, and small quantities of light-coloured zinc blende, and, it is said, can be dressed to 16 per cent. pure galena.[52]

(24) *Lake Superior Group of Deposits, Ont.*

Along the north shore of lake Superior there occur a number of lead, zinc and silver veins which resemble one another in many respects. They seem to be allied more closely to the deposits of this group than to those of any other group in this classification. Some of them seem to represent a transitional form between

[50] C. H. Smyth, Jr.: "The Rossie Lead Veins," School of Mines Quarterly, Vol. XXIV, 1902-3, pp. 423 et seq.

[51] C. H. Smyth, Jr.: "The Rossie Lead Veins," School of Mines Quarterly, Vol. XXIV, 1902-3, page 426.

[52] Geol. Sur. Can., N.S., Ann. Rep., Vol. VI, p. 84 S.

the types described under Intermediate and Low-Temperature deposits. Usually a certain amount of quartz occurs in the gangue; the galena is frequently argentiferous; argentite is not uncommon; and zinc blende is in places the chief ore mineral. These veins pass gradually, by the increase of the silver content, into silver deposits of the well-known Silver Islet type.[53]

Only the most important from the point of view of lead and zinc are described in this report. The so-called silver veins, however, also contain galena and sphalerite.

(*a*) Silver Lake Location, Thunder Bay—(Lead-zinc)

Silver lake lies at a distance of about six miles northward from the head of Thunder bay, and at an elevation of about 500 feet above lake Superior. A short distance to the west of it there is an enormous brecciated vein, some 250 feet in width, composed of masses of the country rocks cemented together with quartz and some barytes and calcspar, and holding small quantities of galena, copper and iron pyrites and blende. This has been traced for about three miles. In approaching Silver lake it contracts rather abruptly, but sends out several branches to the eastward, of which four or five have been followed for considerable distances and are found to be much richer in galena and blende than the great vein. The latter is on a line of dislocation which increases in going west and appears to die out to the eastward. The downthrow is on the north side, and brings the indurated calcareous marls of the Nipigon series on that side down to the level of the iron-ore beds (at the base of the series) on the south side, amounting to 400 feet, or upwards, on this location. The specimens are taken from a shaft sunk on a vein on the line of the eastward continuation of the dislocation, at a point from one to two hundred yards south of Silver lake, and about eighty feet above its level. Here the vein runs N. 80° E. and may be about six feet wide, but its north wall is not well defined. The gangue consists of calcspar, with some quartz and barytes, and holds a good proportion of galena and blende.[54]

(*b*) Island No. 2, Silver Lake—(Silver-lead-zinc)

Specimens of galena weighing about seventy-five pounds. The island known by the above description is traversed by one of the branch veins referred to under the last heading. The vein runs nearly east and west, and is described as being about six feet wide, with good walls. The gangue is chiefly calcspar, with some quartz, barytes, etc., carrying a fair proportion of galena, accompanied by blende. Two samples of dressed ore assayed by Prof. Chapman gave an average of 57.53 per cent. of lead and 202.6 dwt. of silver per ton of 2,000 pounds.[55]

(*c*) Paresseux Rapids, Kaministikwia River—(Lead)

Large vein varying from 10 to 25 feet in width which crosses the Kaministikwia in a W.S.W. course about the line between lots 20 and 21, Range 1, N. in the township of Paipoonge. At this locality the blende may be in sufficient quantity to prove of economic value. Besides the blende the vein is composed of barytes, quartz, calcspar and fluorspar, with a little copper pyrites, iron pyrites and galena. It is supposed to be identical with the Shuniah vein, the large vein on location M. at the northwest corner of Neebing [township.][56]

(*d*) Blende Lake, Thunder Bay—(Zinc)

Vein about eight feet wide on the shore of Blende lake, a small sheet of water about 1½ miles N.N.W. of the head of Thunder bay. The bay runs east and west. The north wall consists of ferruginous siliceous clay slates belonging to the Nipigon series, and the

[53] Geol. Sur. Can., Ann. Rept., 1887, Part H, Report on Mines and Mining on Lake Superior, by E. D. Ingall.

[54] Descriptive Catalogue of a Collection of the Economic Minerals of Canada. and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876, p. 32.

[55] Idem, p. 32. [56] Idem, p. 30.

south wall of dioritic schist of Huronian age. The blende (which is of a dark colour), occurs in curving ribs two to four inches thick, transverse to the plane of the vein, in a gangue of white calcspar, with some galena and iron and copper pyrites. Silver is also said to have been detected in it. A shaft has been sunk upon it to a depth of twenty-five feet.[57]

(*e*) Location VI L, Black Bay—(Lead)

The above location touches the northwest corner of the township of Dorion. The vein is described by the owner as being about 12 feet wide, running northeastward and underlying to the southeastward. A parallel vein, underlying towards the first is said to occur at about twenty rods to the southward, and both are stated to have been traced for a considerable distance on the surface. The gangue is calcspar with quartz and barytes, and besides the galena it contains more or less copper pyrites.[58]

(*f*) St. Clair Location, Black Bay—(Lead)

This location comprises parts of lots 10 and 11 in the 6th and of 9 and 10 in the 7th concessions of the township of Dorion. As stated in a report by Captain John C. Harkness, the vein is twelve to twenty feet wide, composed of calcspar, quartz and gossan, and carries promising quantities of galena. It runs a little north of east, has been traced for thirty claims on the surface, and is situated on high ground favourable for mining, at about four miles from Black bay. The country rock is said to be red indurated marl, associated with reddish granite, with a high bluff of coarse grey trap a short distance to the northward.[58]

(*g*) Enterprise Mine, Black Bay—(Lead)

This mine is situated on mining lot C, in the township of McTavish, about three miles west of Black bay. The vein, which runs N. 60° E. and S. 60° W., cuts indurated red marl forty feet thick, underlain by grey quartzose sandstone, flanked by red granite at about 300 yards to the northward. At the surface there was a thickness of four feet of solid ore. . . . According to Professor Chapman of Toronto, this ore contains 47½ per cent. of lead and 10 per cent. of copper, together with an average of 17 dwt. 12 gr. of gold, and 2 oz. 2 dwt. of silver to the ton of 2,000 lbs. On entering the sandstone, the vein became smaller and poorer, but at 100 feet from the surface it had opened out to seven feet in width, and contained bunches of ore like specimen six. Several hundred barrels of ore were shipped from this mine in 1875, and work is still being carried on.[58]

(*h*) McKellar Island, Thunder Bay—(Zinc-silver)

. . . situated about one mile south of the southeast end of Pie island, Thunder bay . . . vein forty-five feet in width, consisting of alternating bands of white barytes and coarse calcspar, with blende, silver glance, and native silver in one of them. The wall-rock is massive dark crystalline diorite.[59]

(*i*) Dorion Township, Black Bay—(Zinc)

Three specimens of blende [from lot 10, concession VI, Dorion township]. The vein is reported to be about three or four feet wide, and to run NW., and SE. The locality is about four miles west of Black bay. It is not yet worked.[60]

(*j*) Dorion Zinc and Lead Mine, Dorion Township

The vein, which occurs at the contact of the granite and the Keweenawan marls, has a strike of N. 40° W. and a dip of about 70° to the west. It occupies a fracture zone due to a fault which occurred along this contact, the blende and galena impregnating the granite (the footwall) and the Keweenawan (the hanging-wall) in the form of veinlets which fill the fractures for about forty feet from the contact into the granite and fifteen feet into the Keweenawan. The main concentration, however, which is from three to three and a half

[57] Descriptive Catalogue of a Collection of the Economic Minerals of Canada, and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876, p. 30. [58] Idem, p. 32. [59] Idem, p. 36. [60] Idem, p. 30.

feet wide, occurs along the contact, which is the fault plane proper. The galena and blende solutions which were accompanied by silica, calcite and barite, filled the little fissures and cracks formed by the fault, and enlarged them by replacement, the more soluble brecciated material being removed and the ores and gangue minerals deposited in its place. There was considerable development work done at this mine and the vein looked very promising.[61]

B.—Origin of the Calcite-Barite-Fluorite-Galena Veins

In the descriptions of the deposits of this group, no mention has been made of the genesis of the veins. From the point of view of an examining geologist or engineer, the question of origin is very important in that the solution of it enables him to form reasonable conclusions as to the extent and possible change of mineralization in the veins at depth. Since the first twenty-three deposits described in this division form a well-marked structural and lithological group, it was deemed advisable to discuss their origin collectively, after all the field evidence had been presented.

The chief features characterizing these deposits that would require an explanation under any hypothesis of origin are the following:

(1) The veins, with perhaps one exception, strike in a northwesterly direction, cutting across the predominant strike of the country rocks.

(2) The deposits are fillings of fissures and are not replacements of country rocks. Usually they are bounded by very smooth walls, from which the vein material may be very readily broken.

(3) In several cases, these veins are seen to occur in fissures cutting Paleozoic rocks, of as late a date as the early Ordovician (e.g., Beekmantown).

(4) In a few instances the fissures are seen to be fault fissures, on account of the juxtaposition of rocks of different age, in the walls. In most of the other instances, such excellent evidence of faulting was not found, perhaps because it was difficult to detect a displacement in rocks of a somewhat uniform composition. However, a great many of the veins show smooth, slickensided walls, and include, in a matrix of the gangue, abundant horses of country rock. In one or two cases (especially at Rossie, N.Y.) these inclusions show considerable comminution due to grinding. The argillaceous gouge at the Frontenac lead mine is also suggestive of such comminution. These facts are good evidence of differential movement and brecciation.

(5) The vein at the Galetta lead mine occupies a fault fissure, and in one trench the flat-lying Paleozoics may be observed on one side of the vein, and the Archæan on the other. The amount of differential movement has not been worked out. However, it is very important to note that at certain points in this vicinity and in the neighbourhood of Ottawa several well-marked northwesterly-striking faults have been described by R. W. Ells,[62] E. M. Kindle and L. D. Burling.[63] (See Map No. 25c.) It is highly probable that small amounts of galena and fluorite, which have been reported from various points in these localities, have been derived from veins in these fault fissures.

[61] Ont. Bur. Mines, Vol. XV, Part II, 1906, p. 170.

[62] R. W. Ells: "The Physical Features and Geology of the Paleozoic Basin between the Lower Ottawa and the St. Lawrence Rivers;" Trans. Roy. Soc., Canada, Vol. 6, Sec. 4, 1900. pp. 99-120.

(6) It has been estimated [63] that some of these faults in the vicinity of Ottawa and Montreal show a differential vertical displacement of 1,800 to 2,000 feet. These figures afford a very interesting suggestion as regards the depth of the fault fissures, which are mineralized with lead and zinc ores.

(7) Many of the veins outcrop at intervals for long distances along the strike; those at the Frontenac, Hollandia and Galetta lead mines having each been traced, it is believed, for upwards of a mile. A straight line joining the Rossie and Lansdowne deposits and projected northwesterly will be seen (Map No. 25c) to pass very close to the Bedford veins. The strike of this line is not far different from that of the individual deposits. Similarly, a straight line joining the Redwood and Frontenac deposits, if projected northwestward, would pass very close to the Hollandia, Katherine and the Tudor Lake deposits generally. The strikes of the line and the individual deposits would not be very much at variance.

These facts suggest that there may be zones of dislocation extending for considerable distance northwest and southeast across this part of Ontario, and that the deposits may be fillings of parts of these zones.

(8) All of the veins that have been examined by the writer are of the pinch-and-swell type, and it is quite likely that the remaining ones show the same characteristics. Fractures of such a character are usually found in fault zones, where a relative displacement of the walls in any direction along a fracture would produce openings of a more or less lenticular shape.

(9) The chief gangue minerals in this group of veins are calcite and barite. Calcite seems to be more predominant in the wider veins as at the Frontenac, Hollandia and Galetta properties, while barite is more abundant in the narrower ones, as at the Bedford, Union Creek and Crown King prospects.

(10) The veins are of the crustification type, and sometimes this banding is accentuated by the presence of the ore minerals between successive bands of the gangue. The individual bands break very readily from each other.

(11) Fluorite is found occasionally as a gangue mineral. It is reported chiefly from the veins in the Gaspe peninsula and from those north of the Ottawa river in Hull and Buckingham townships. It is also described as occurring in a large vein at the Paresseux rapids, near Fort William, and in the Rossie lead veins.

(12) The chief ore mineral is galena. It usually occurs more or less richly disseminated in clusters and crystal aggregates throughout the gangue. These masses vary in size from small grains to some weighing several hundred pounds. At one or two localities the galena is seen to occur as coarse-grained tabular masses parallel to the crustification of the veins.

(13) Sphalerite usually occurs in more or less amount. In the veins of eastern Ontario and Quebec, it is usually quite subordinate, and is found in the veins chiefly where they cross crystalline limestone. It is almost entirely of a brownish colour, very similar to the ore of the Mississippi Valley region. In the Lake Superior group of deposits (No. 24 above), sphalerite becomes more abundant, and in a few of them it constitutes the chief economic mineral.

(14) Accessory minerals in the veins consist of pyrite (or marcasite?), chalcopyrite and quartz.

[63] Geol. Sur. Can., Museum Bulletin No. 18, 1915.

(15) As a general rule, especially in the eastern group, the ore minerals may be described as non-argentiferous. Frequently, however, they contain as much as one ounce of silver to the ton of galena. This proportion is not very different from that prevailing in the sedimentary lead and zinc deposits of Missouri and the Upper Mississippi Valley region.

(16) In the Gaspe peninsula of eastern Quebec, dikes of greenstone are found cutting the limestones of the Ordovician, in which the mineral deposits occur. This areal association is exceedingly interesting, as it shows that in certain localities igneous rocks occur which might have afforded materials for the formation of the veins.

(17) In the vicinity of Madoc, Ontario, some veins, consisting very largely of fluorspar, are found cutting both the pre-Cambrian and the Ordovician. It is possible that these veins belong to the same group as the ones under discussion. Sufficient exploration has not been done on the deposits to show whether galena and sphalerite are present. Calcite occurs in the veins.

The Hypothesis of Origin by Meteoric Waters

The possibility of the extension of these veins to a considerable depth is a very important factor in estimating the value of the deposits from the point of view of development. In order to draw the most reasonable inferences as to such extension, it is necessary to formulate a hypothesis that will afford an explanation of the chief vein characteristics summarized above.

Primarily, it is important to know whether the deposits have been formed entirely by meteoric waters, or whether magmatic after-effects have had an important bearing on the origin of the veins. If the former be the true explanation, it is reasonable to suppose that the veins do not attain any considerable depth. On the other hand, if ascending hot waters have played an important part, it is quite probable that the mineralization may continue to great depths, and may vary considerably in character.

In the classification adopted for this report, these vein deposits have been classed as having an origin probably independent of igneous after-action. This seems to be the most natural conclusion, as to genesis, to be derived from a study of the individual deposits. For instance, the vein at the Frontenac, or Hollandia or Galetta lead mine, is of a very marked crustification type. No minerals are present in the veins that might not readily have been obtained by a leaching of the associated crystalline limestones. The veins themselves closely resemble in character the old lead veins of the upper parts of the Wisconsin-Illinois-Iowa deposits, which are recognized to be of meteoric origin. As a general rule, the galena and sphalerite of the Ontario-Quebec group are non-argentiferous. That is to say they contain silver only in minor quantities not of economic value. This is characteristic of galena and sphalerite veins of known meteoric origin. On the other hand, galena and sphalerite veins of igneous origin usually contain upwards of ten ounces of silver to the ton of sulphides. The veins have been found cutting lower Ordovician limestones. In the southeastern Ontario region, where these veins are specially abundant, there are no known evidences of igneous intrusion as late as the Ordovician, to whose influence the origin of the veins might be

ascribed. Usually the veins do not show the intimate mixture of minerals that very frequently is the case in deposits of igneous origin. The sphalerite is of the light to resin brown colour that usually characterizes the zinc blende of meteoric origin.

The above-mentioned characteristics obtained from the study of the chief individual deposits, suggest an origin for the vein material by waters of purely meteoric origin. The argument for this case seems to be a fairly strong one, and one that will probably meet with general approval. The analogy of the veins to deposits of meteoric origin in the United States that have been carefully studied is exceedingly suggestive.

Probable Origin of the Fluorite

After a study of the veins of this group, as a group rather than as individual occurrences, and after the correlation of the evidence as given in the tabulated summary above, a different mode of origin for these veins has suggested itself, one which appeals strongly to the writer. Consequently, the suggestion is made that the veins owe their origin to a combination of the influences of meteoric and magmatic waters. It is conceived that in all probability the vadose circulation leached much of the metallic and non-metallic constituents of the veins from the Paleozoic and pre-Cambrian rocks, chiefly the limestones, that occur in association with the veins. Calcite and barite might very readily be derived from this source. The limestones of the pre-Cambrian especially contain perceptible amounts of the sulphides of zinc, lead, iron and copper.

The presence of considerable fluorite in some of the veins, however, cannot readily be explained by a process of leaching of the limestones. Prof. Van Ingen pointed out in an address before the Geological Society of America at its Philadelphia meeting in 1914 that fluorine occurs in the teeth and bones of marine animals, and suggested that this source might afford a supply of fluorite for some deposits. It hardly seems reasonable that a selective leaching process in this limestone could have proceeded far enough to bring about the results observed in the veins. Igneous rocks also contain certain amounts of fluorine, especially in apatite. This might be a possible source of the fluorite in the veins which intersect igneous rocks. But it is important to note that some of the veins containing fluorite abundantly occur up in the Ordovician limestones, a considerable distance above the underlying pre-Cambrian. Meteoric waters could not very well have carried this fluorite upwards from the pre-Cambrian igneous series. The evidence, therefore, seems to favour some other origin for the fluorite.

An interesting suggestion concerning the origin of the fluorine is afforded by its occurrence in the calcite-barite-galena veins of eastern Quebec where the Ordovician is cut by intrusives chronologically related to the Taconic revolution. It is possible that the presence of the fluorine in the vein minerals has a genetic relation to the igneous activity of post-Ordovician age, which produced important results in the Province of Quebec, but which, as far as known, did not affect Ontario. In this connection it is interesting to refer to the occurrence of the

fluorite veins in southern Illinois[64] and western Kentucky.[65] In these districts also the ores occur largely as fillings of fault fissures or as cements for breccias in zones of dislocations. Galena, sphalerite, pyrite, marcasite, chalcopyrite, calcite, barite and some quartz occur associated with the ore material, which is chiefly fluorite. Dikes of peridotite cut the formations containing the veins and it has been suggested by H. F. Bain[64] that possibly the fluorine may have been introduced into the veins by waters that derived it from the cooling igneous rocks. It is well known that the important fluorspar deposits of England and Saxony also occur in limestones, gneisses, schists and slates, which in both cases are intersected by basic dikes.

Vein Fillings of Fault Fissures

It is probable that the veins of the group under discussion occur as fillings of fault fissures and zones of dislocation. Very frequently these veins have been found to be at least half a mile in length. The location and strike of the individual deposits as shown on Map No. 25c indicates that perhaps the displacement zones are much more extensive than are indicated by the known continuance of each individual deposit. They may even extend for several miles in a northwest direction across southeastern Ontario. If so, the natural conclusion is that they must extend to very considerable depths since it is generally accepted that the lateral extent of a fissure is to some degree a measure of its depth. Again, the data obtained by E. M. Kindle and L. D. Burling[66] in their work on the fault zones of southeastern Ontario, show that several of the faults in the vicinity of Montreal and Ottawa show a relative vertical displacement of upwards of 2,000 feet. It is believed by the writer that the calcite-barite-galena veins occupy fault fissures of this type and age. If this is the case, therefore, it is probable that many of these fissures extend to depths where they might tap the circulation of hot solutions carrying materials obtained ultimately from magmatic waters.

Suggested Hypothesis for Origin of these Veins

From a consideration of the evidence given above, therefore, the following working hypothesis is suggested as to the genesis of this type of veins:

The vein material represents a combination of substances obtained from meteoric and magmatic waters. Meteoric solutions possibly leached calcium, barium, lead, zinc and iron compounds from sedimentary and igneous rocks and constituted the chief ground water circulation. At some time later than the Ordovician there was a period of moderate to severe earth stresses which resulted in the crumpling and folding of the strata in Quebec, and considerable normal faulting in regions farther distant from the centre. Igneous activity probably was an accompaniment of this period of readjustment. The deep fractures that were formed at this time allowed a somewhat deep circulation of the ground waters, and an easy egress for hot ascending solutions. These hot solutions possibly contained some fluorine, which is common as an igneous after-effect. A union of

[64] The Fluorspar Deposits of Southern Illinois; by H. F. Bain, U.S.G.S., Bull. 255, 1905. Fluorspar Deposits of Southern Illinois; by S. F. Emmons: Trans. Am. Inst. Min. Eng., Vol. 21, 1893, p. 52.

[65] The Lead, Zinc and Fluorspar Deposits of Western Kentucky; by E. O. Ulrich and W. S. T. Smith, U.S.G.S., Prof. Paper 36, 1905.

[66] Geol. Sur. Can., Museum Bulletin No. 18, 1915.

these solutions in the fault fissures which would constitute main channels of circulation would, therefore, provide the material necessary for the formation of veins of the calcite-barite-galena-fluorite type. The actual deposition was no doubt controlled by the conditions of temperature and pressure, and by the varying composition of the solutions.

If this hypothesis be correct, it is probable that the veins will show considerable vertical extent. Of course it is not suggested that the mineralization would extend to the bottom limits of the fracture zones, nor that it would be constant. On the other hand, there is every reason to believe that the mineral composition of the veins would vary considerably in depth.

In connection with the above discussion it is interesting to recall a short paper in "Economic Geology" by L. V. Pirsson,[67] and another a short time later by J. E. Spurr[68] on the "Origin of Certain Ore Deposits." Dr. Pirsson suggests that possibly igneous emanations from deeply concealed magmas may have been responsible for the peculiar composition of certain ore deposits which occur in districts where igneous rocks are not known to come to the surface. He even intimates that the mid-Mississippian deposits of zinc and lead may have derived some of their constituents from this source. On account of the similarity of the views expressed therein to the suggestion made above with reference to the origin of the calcite-barite-galena veins of Ontario and Quebec, a few paragraphs from the paper are here included. The suggestions made by Dr. Pirsson seem to accord much more closely with the conditions in Ontario and Quebec than, for example, with those in Missouri.

Moreover, the dissimilar properties of the ores in different districts, the variable relations between lead, zinc and copper in closely related ones, the occurrence of nickel and cobalt, and in places of fluorite, which latter when occurring in large masses could scarcely represent an extract from the teeth and bones of animals, etc., still remain unexplained. . . .

As there is every degree between eruption with catastrophic violence to quiet outwelling of magma of mixed volatile and non-volatile substances under proper conditions, so there should be all gradations in the mode of rising of the gaseous portion through the shattered lithosphere and its escape at the surface.

Furthermore, as it is natural to believe that magma, perhaps in the pseudo-rigid but potentially liquid form conceived by Iddings[69] must everywhere underlie the outer rock zone, so everywhere there will be a tendency for it to rise upward when opportunity permits. One of the first effects of relief of pressure on its upper surfaces would be the liberation of the volatile constituents. It may well be that in many places no further action than this happens. All the shiftings and movements of the lithosphere would then tend in variable degree, to be attended by upward movement of gaseous constituents, and in the same measure the passage of magma upward would be heralded by the development of increase of solfataric or fumarolic activity at the surface; a fact well known in volcanic regions. This quiet working upward of volatile matters may then be considered as the mildest phase of volcanic action with which we are acquainted and one which has happened, is happening, or will happen, practically everywhere over the world. To it we may ascribe in large measure peculiarities seen in the composition of many mineral springs and waters in otherwise apparently non-volcanic regions.

The application of this principle, the quiet upward movement of volatile magmatic material, if it be admitted, in explaining the origin of the ore deposits previously mentioned, is evident. If sulphide ores have been deposited from acid emanations in those cases where the connection with intruded bodies of magma is clear and unmistakable from the visible presence of the latter, it seems a natural and inevitable step to ascribe those instances

[67] L. V. Pirsson: "Origin of Certain Ore Deposits." Econ. Geol., Vol. 10, No. 2, 1915, p. 182.

[68] J. E. Spurr: "Origin of Certain Ore Deposits." Econ. Geol., Vol. 10, No. 5, p. 472.

[69] "The Problem of Volcanism," p. 164, 1914.

where no igneous rocks are seen or known in connection with them to such emanations working upward from magma in the depths below. It does not appear necessary to establish the connection that magma should have ever reached the surface or, perhaps, even the upper zone of intrusion in the lithosphere, though naturally where this has happened the chances for ore deposition would be greatly increased. . . .

As to the mid-Mississippi area which has served as a basis for this suggestion, it can be said that evidences of the milder modes of igneous activity, in addition to the occurrence of the ores themselves, are not wanting in many places, while in some it has assumed a more active and evident form. Thus in central Arkansas are many intrusions of syenites and related alkalic rocks of late Cretaceous age; there are also the occurrences of diabase, porphyrites, etc., in the eastern Ozarkian uplift of Missouri; of peridotite dikes in Kentucky and Illinois, with which are associated ores and fluorspar, the latter in huge masses, and indicative of fumarolic action from magma below. The great volumes of "sulphurous" gases, which issued from the ground and whose presence is mentioned by so many observers at the time of the New Madrid earthquakes in 1811-12, may possibly have had such an origin, and afford an example of the outbreak of magmatic vapours from below. It is not suggested that they were the cause of the seismic phenomena, but merely attendant upon it; the disturbance and displacements of the rock masses giving them an opportunity to escape. All of these instances and others that might be cited appear to point in the same general direction.

C.—Gash Veins and Impregnations in Paleozoic Limestones

(1) *Albemarle Zinc Mine, Ont.*[70]

(*a*) Location: This property is located on lot 30, concession II, of the township of Albemarle, Bruce county, Ont., about eight miles from Wiarton.

(*b*) Ownership: The mining rights to 100 acres are owned by the Albemarle Zinc Company, of which George Bourne, of Wiarton, is Manager.

(*c*) Operation: Small amounts of development work have been done at intervals since the summer of 1910, consisting of surface trenching and the sinking of a shaft to a depth of thirty feet. There are several open pits.

(*d*) Occurrence of the ore:

Zinc blende occurs filling pore spaces and cavities, and partially replacing fossils and the country rock. The greatest accumulation of ore was found in cavities open to the surface and evidently dissolved out by meteoric water. Loose ore was mixed with pebbles and earthy materials, and in one place as much as 110 pounds of ore were obtained from a single pocket.[71]

(2) *Lake Mistassini, Que.*—(*Lead-zinc*)

(*a*) Location: At the northeastern corner of the Chibougamou region of Quebec, between lakes Wakonichi and Mistassini, two miles north of the Hudson's Bay Post.

(*b*) Description:

The Mistassini galena and blende occur in a rather flat-lying limestone, which has received some flexures and shearing; the galena and blende are found in small spots and splashes in these flexures. The existence of these minerals, associated with limestone, indicates a possibility of larger deposits elsewhere in the Mistassini basin.[72]

[70] Ont. Bur. Mines, Vol., XXIV, Part I, 1915, p. 151.
[71] Geol. Suy. Can., Summ. Rept., 1912, p. 281.
[72] Report on the Geology and Mineral Resources of the Chibougamou region, Quebec, Dept. of Colonization, Mines and Fisheries, Prov. of Quebec, 1911, p. 185.

3. Anamorphosed Low-Temperature Deposits

At several localities within the pre-Cambrian shield in southeastern Ontario deposits of lead and zinc sulphides occur disseminated through crystalline limestones. In a few of the localities these disseminations are sufficiently segregated to constitute sulphide deposits of probable economic value. In other places the ore minerals are merely richly disseminated, and not in bodies that give promise of developing into deposits of commercial importance. Two examples of this group are discussed in detail in the following section.

All limestones are believed to contain zinc and lead in at least very small amounts. Traces of these metals have been found in most limestone analyses. The crystalline limestones of the pre-Cambrian of southeastern Ontario and western Quebec, many of which belong to the Hastings or Grenville groups, very commonly contain the sulphides of these metals disseminated through them in grains of recognizable proportions. It is believed by the writer that compounds of zinc and lead were deposited in these limestones syngenetically with the calcium carbonate in minute quantities in a manner similar to the occurrence of zinc and lead in unmetamorphosed Paleozoic limestones. The great regional metamorphism which these early pre-Cambrian limestones have at various periods undergone, is believed to have afforded conditions favourable for the segregation of the minute quantities of the zinc and lead minerals present into disseminated grains of distinguishable size. That is to say, limestone recrystallizes so readily under conditions of differential stress, that each period of regional deformation was accompanied by the development of flowage conditions in the limestone. These flowage conditions, therefore, afforded an opportunity for the like particles of lead and zinc minerals to segregate into larger grains.

Although crystalline limestones are abundant throughout the area covered by this Report, the presence of galena or sphalerite in commercial quantities within their masses is known in only a very few cases. Two of these examples have come to the attention of the writer, and careful field investigations have led to the belief, that in these cases the segregation process has been enabled to attain such large proportions that the final result is not a disseminated deposit of ore grains of recognizable size, but a deposit in which the grains have been so closely segregated as to constitute a series of lenticular masses of almost solid ore minerals. Extraordinary conditions seem to have accounted for the opportunity of increased segregation, and these conditions are believed to have been the greatly increased heat and pressure induced in the crystalline limestones by the intrusion into them of large masses of granite and gabbro which occur in the immediate vicinity of the zinc and lead deposits. The limestone near the granite and gabbro contacts is usually very coarse grained, and the ore minerals are chiefly developed in these coarse-grained phases. For reasons explained in the discussion of the individual deposits, the granites and gabbros are not believed to have contributed anything in the way of ore minerals to the limestone.

On the other hand, there are large areas in southeastern Ontario and western Quebec where apparently the same limestones are intruded by granite without the known presence of zinc and lead sulphide deposits.

The deposits described below are conceived by the writer, therefore, to be merely anamorphosed representatives of limestones which contained within themselves the elements that finally were segregated into the sulphide bodies.

(1) *Long Lake Zinc Mine, Frontenac County, Ont.*

(*a*) Location: This property has formerly been known as the Olden or Richardson zinc mine and is located in lot 3, concession V, and lot 3, concession VI of the township of Olden, Frontenac county, Ontario. The nearest railroad stations are Tichborne Junction, eight miles distant, on the Montreal-Chicago and Kingston and Pembroke lines of the C.P.R., and Mountain Grove, about seven miles distant on the Toronto-Peterborough-Montreal line of the C.P.R. A siding on the latter line has been constructed at a point four miles north of the mine. The property is about thirty-six miles north-northwest of the city of Kingston.

(*b*) Ownership and operation: The mineral rights of 196½ acres underlying the locations mentioned above are owned by James Richardson & Sons, Limited, grain merchants, Kingston, Ontario. The property has been operated in a desultory fashion by the owners since about 1897, but no systematic exploration has yet been carried out to determine the extent of the mineralization. During the winter of 1914-1915 the property was under option to a group of United States zinc interests known as the Long Lake Zinc Company, and the underground workings were unwatered and a thorough examination was made by the writer. In May, 1915, the property was returned to the owners, and is still idle at the time of writing.

(*c*) Geology: The mine lies within the area of the pre-Cambrian shield of southeastern Ontario, about sixteen miles north of the overlapping edge of the Paleozoic. The rocks are well exposed, and the succession in its broad features appears to be as follows:

PALEOZOIC	Sandstone: Upper Cambrian
	Unconformity
PRE-CAMBRIAN	Granite: Moira (?)
	Intrusive contact
	Gabbro and diorite gneisses
	Intrusive contact
	Crystalline limestones
	Quartzites
	Acidic gneisses
	Green schists

Of the last four members of the succession, only the crystalline limestone occurs in the immediate neighbourhood of the mine. It is the oldest rock in the mine area. It is usually coarsely crystalline, and occurs in elongated strips, striking about N. 20° E., magnetic, seldom more than a few hundred feet in width. The limestone has been intruded by a gabbro, which shows a slightly gneissic structure.

The banding of this gneissic gabbro is parallel to the northeasterly trend of the limestone, and in no place is the gabbro seen to cut across the limestone, except in dikes. Slight irregularities along the contacts, however, give evidence of the intrusive nature of the contact. Both the limestone and the gabbro, as well as the associated quartzites, gneisses and green schists, have been intruded by a massive, coarse-grained granite, which underlies great stretches of country to the north and south. Dikes of aplite and pegmatite from this parent source traverse both the limestone and the deposits of zinc ore.

(*d*) Development: The property has been explored throughout a length of 3,500 feet by surface stripping and underground workings. Practically all of the development has been done at points where the ore came to the surface, and is of the following character:

(1) Five shafts on the ore body varying from 60 to 125 feet in depth.
(2) About 350 feet of drifting, mainly in ore.
(3) Three open cuts up to 60 feet long and 40 feet deep.
(4) Twenty-five pits and trenches varying in depth from 3 to 30 feet. (See Fig. 3.)

In addition to this, about one thousand feet of diamond drilling, distributed in shallow holes mainly between the east and mill shafts, was accomplished during the winter of 1914-1915.

(*e*) Nature of the ore and gangue: The ore is chiefly zinc blende of a dark chocolate-brown colour, with small amounts of galena. In places, pyrite is a common associate of the ore, while pyrrhotite and chalcopyrite are present to a slight extent. Where the sphalerite is coarse grained, it is almost entirely free from the other sulphides, but wherever the fine-grained phase of the ore predominates, it is usually rather intimately mixed with the sulphides of lead, iron and copper, as well as with the gangue minerals. An assay of a sample of the ore, taken at random from the various dumps and outcrops, gave a silver content of 1.05 oz. per ton of 35.4 per cent. zinc concentrates. The ore, therefore, is from a commercial point of view non-argentiferous.

The chief gangue mineral is the calcite of the country rock. Greenish diopside and quartz are also of common occurrence in association with the fine-grained variety of the ore.

The records of shipments made from the property show that hand-jigged concentrates have been made that assayed 50 per cent. zinc and 8 to 9 per cent. lead. Ore was also hand-picked that assayed 40 to 44 per cent. zinc.

(*f*) Occurrence of the ore: The ore occurs entirely within the crystalline limestone in horizons parallel to its banding. Thickened and flattened "lenses" of the sulphides are the characteristic feature of the deposit, but ore grains are usually disseminated more or less thinly through the limestone, in these same general horizons. On careful inspection it is seen that all gradations exist between the thinly disseminated ore and the apparently massive "lenses." Even these so-called "lenses" contain disseminated grains of the gangue minerals throughout their mass. Their boundaries are not sharply defined, but exhibit a gradation

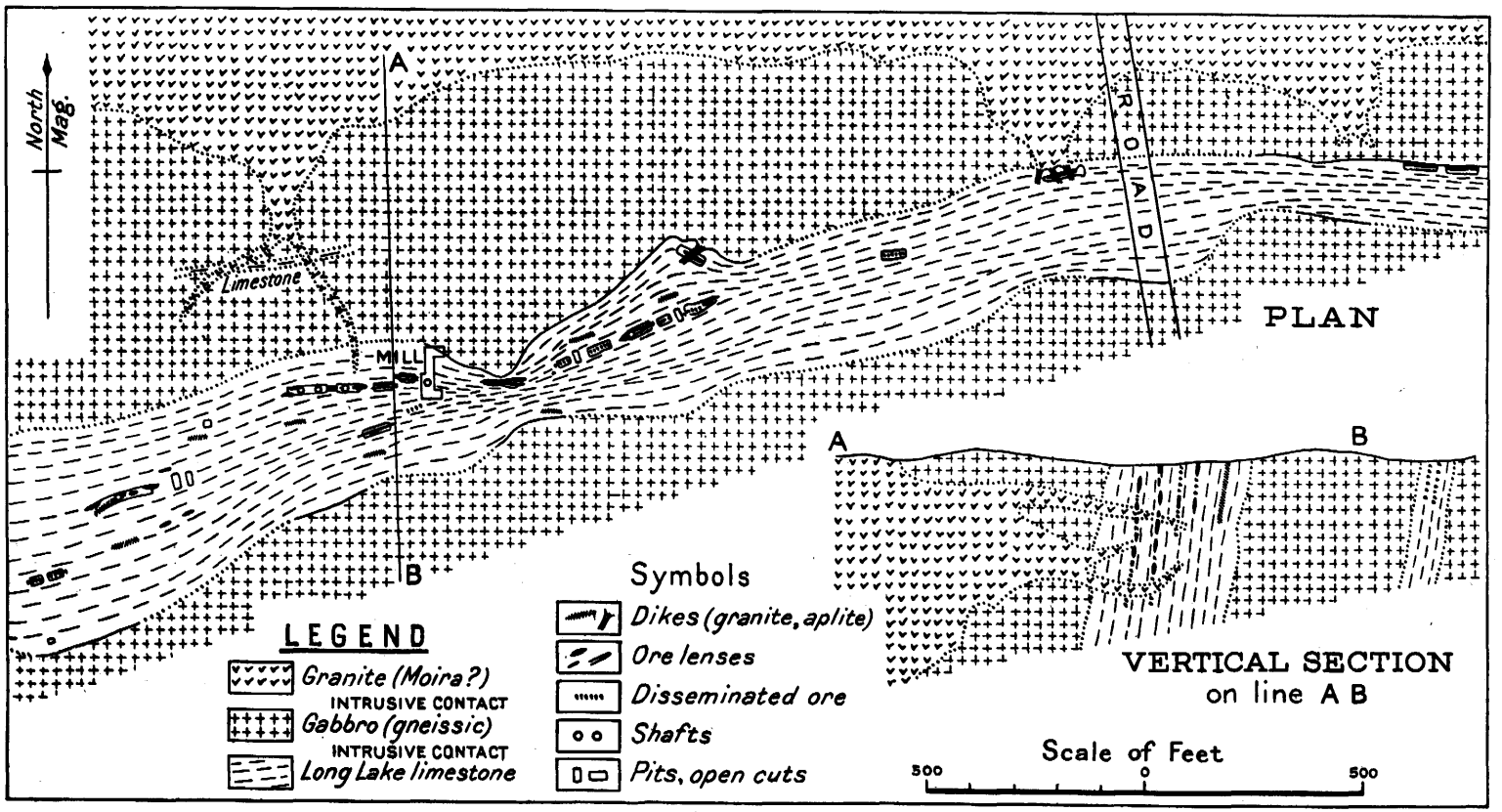

Fig. 3—Long Lake Zinc Mine, Frontenac county, Ont.

NOTE.—Geological boundaries in the above sketch map are accurate only where shown in full lines. The granite-gabbro contact in particular is very approximate. Broken lines within the limestone area do not represent the strike of single bands of limestone, but are drawn to indicate in general the tendency of the bands to conform with the strike of the gabbro-limestone contact.

from dominant ore to dominant gangue minerals within the space of an inch or two. Consequently it appears that the lenses are in reality made up of closely segregated sulphide disseminations.

There are three main ore horizons, as shown on the accompanying sketch (Fig. 3). The two chief ones lie within the limestone band, at distances averaging about 80 and 200 feet south of the northern contact. Another horizon occurs within the limestone along the northern contact, as shown in some trenches on the eastern half of the map. No mining has been done on this latter horizon. In addition to these main localities, thin "lenses" and disseminations of zinc blende may be seen at other horizons within the limestone.

The "lenses" vary considerably in size and shape. In general they are approximately circular. They vary in length from 5 or 6 feet to about 100 feet, and in width from a few inches to 14 feet. At the western shaft a "lens" of ore has been mined that was 14 feet thick at the surface, and which outcropped throughout a length of 90 feet. This "lens" was mined to a vertical depth of about 40 feet, and constituted the largest individual body so far encountered. It consisted very largely of the coarse-grained variety of zinc blende, which was hand-picked for a shipping product. Other "lenses" of considerable size have also been encountered from time to time.

The individual "lenses" may pinch and swell several times between their centre and circumference. As a general rule, they appear to be entirely separate bodies with no connection between adjacent ones. Exceptionally, small connecting links may be seen between two comparatively large bodies of ore. These connecting links usually consist of thinly disseminated zinc blende and pyrite along one or two thin bands of limestone, and may escape the attention of one not searching for them.

The disseminated character of the ore and its intimate association with the gangue minerals strongly suggest that in their present condition both ore minerals and limestones are of simultaneous crystallization. Dikes of granite and gabbro from the main intrusive masses cut both ore and limestone, and prove that the ore minerals were in their present form within the limestone previous to the period of dike intrusion. The dikes, therefore, do not interfere with the extension of the ore.

(*g*) Genesis of the ore:[13] As suggested in the introduction to this division, the deposits, of which the Long Lake mine is the best known example, are believed to be simply the segregated products of the disseminations of sulphide minerals originally present in the limestones. There is no evidence indicating that the ore minerals have been introduced from any foreign source. The intrusive rocks are believed to have produced conditions of high temperature and pressure within the limestone of such a character as to allow the sulphide constituents to segregate into "lenses."

[13] A complete discussion of the evidence for this hypothesis will be given in an article by the writer to be published in a forthcoming number of "Economic Geology," entitled "Ore Genesis and Contact Metamorphism at the Long Lake Zinc Mine, Ontario."

(2) *Sheffield Township Zinc Deposit, Addington County, Ont.*

(*a*) Location: This prospect is situated on the west half of lot 10, concession XV, Sheffield township, county of Addington, Ontario. The nearest railway station is Enterprise on the new Chicago-Montreal Lake Shore line of the Canadian Pacific railway, and is eight miles distant.

(*b*) Geology: The rock succession is very similar to that at the Long Lake zinc mine. White crystalline limestones, associated with micaceous gneisses are intruded by a massive, coarse-grained granite, all of pre-Cambrian age.

(*c*) Nature of the ore and gangue minerals: The chief ore mineral is zinc blende of a dark chocolate-brown colour. This is associated with small amounts of galena and pyrite. The gangue is chiefly crystalline limestone, with minor quantities of lime silicates.

(*d*) Occurrence of the ore: The sphalerite occurs disseminated through the crystalline limestone near the granite contact in grains varying from the size of a pea to that of a walnut. No massive ore was seen. Certain belts within the limestone seem to be richly mineralized, while others are almost barren.

(*e*) Development: Scarcely any development has been done on the property. There are two pits on the zone of mineralization, one of which is about eight feet and the other two feet deep. The mineralized belt may be followed by intermittent outcroppings for at least 150 feet. In no place is this belt wider than five feet.

(*f*) Genesis of the ore: It is believed that the zinc-sulphide minerals were original constituents of the limestone, and were simply segregated at the time of the granite intrusion, which produced conditions of flowage in the limestone. No specific data as to the origin of this deposit was obtained, but all the evidence suggests that it is an occurrence similar to the disseminated phases of mineralization at the Long Lake zinc mine.

BOUNTIES ON LEAD AND ZINC PRODUCED IN CANADA

In order to encourage the production of the refined metals in Canada from Canadian ores, and to stimulate the exploration and development of Canadian deposits, the Dominion Parliament has placed bounties on zinc and lead produced in Canada from home ores. For the purpose of general information the following statements concerning the operation of these bounties are here introduced.

The Lead Bounties Act, 1913

An Act respecting the payment of bounties on Lead in Lead-bearing Ores mined in Canada.

(*3-4 George V. chap. 29. Assented to 6th June, 1913.*)

Whereas, under the provisions of chapter 31 of the statutes of 1903 and of chapter 43 of the statutes of 1908, as amended by chapter 37 of the statutes of 1910, the amount of bounty payable on lead contained in lead-bearing ores mined in Canada was not to exceed two million four hundred and fifty thousand dollars; and whereas the time within which the said amount is payable for the purpose aforesaid expires, under the provisions of the said chapter 43, on the thirtieth day of June, nineteen hundred and thirteen, and there will

then remain unexpended of the said sum approximately six hundred thousand dollars; Therefore His Majesty, by and with the advice and consent of the Senate of the House of Commons of Canada, enacts as follows:—

1. This Act may be cited as *The Lead Bounties Act, 1913.*

2. The Governor-in-Council may authorize the payment of a bounty of seventy-five cents per hundred pounds on lead contained in lead-bearing ores mined in Canada, on and after the first day of July, nineteen hundred and thirteen, such bounty to be paid to the producer or vendor of such ores; Provided that the sum to be paid as such bounty shall not exceed two hundred and fifty thousand dollars in any year ending on the thirtieth day of June; providing also that when it appears to the satisfaction of the Minister charged with the administration of this Act that the standard price of pig lead in London, England, exceeds fourteen pounds ten shillings sterling per ton of two thousand two hundred and forty pounds, such bounty shall be reduced by the amount of the excess.

The total amount of the bounty payable under the provisions of chapter 31 of the statutes of 1903, chapter 43 of the statutes of 1908 (as amended by chapter 37 of the statutes of 1910), and of this Act, shall not exceed two million four hundred and fifty thousand dollars.

3. Payment of the said bounty may be made from time to time to the extent of sixty per cent. upon smelter returns showing that the ore has been delivered for smelting at a smelter in Canada. The remaining forty per cent. may be paid at the close of the fiscal year, upon evidence that all such ore has been smelted in Canada.

2. If at the close of any year it appears that during the year the quantity of lead produced, on which the bounty is authorized, exceeds sixteen thousand six hundred and sixty-seven tons of two thousand pounds, the rate of bounty shall be reduced to such sum as will bring the payments for the year within the limit mentioned in section 2 of this Act.

4. If at any time it appears to the satisfaction of the Governor-in-Council that the charges for transportation and treatment of lead ores in Canada are excessive, or that there is any discrimination which prevents the smelting of such ores in Canada on fair and reasonable terms, the Governor-in-Council may authorize the payment of a bounty, at such reduced rates as he deems just, on the lead contained in such ores mined in Canada and exported for treatment abroad.

5. If at any time it appears to the satisfaction of the Governor-in-Council that products of lead are manufactured in Canada direct from lead ores mined in Canada without the intervention of the smelting process, the Governor-in-Council may make such provision as he deems equitable to extend the benefits of this Act to the producers of such ores.

6. The Governor-in-Council may make regulations for carrying out the intention of this Act.

7. The bounties payable under the provisions of this Act shall cease and determine on the thirtieth day of June, one thousand nine hundred and eighteen.

Owing to the high price of lead prevailing in London during the past two years, the bounty paid during this period amounted only to $11,496. The amount still available, Dec. 1, 1915, therefore, for the payment of this bounty is $625,171.

Proposed Bounty on Zinc

The following is a copy of a resolution introduced in the Dominion House of Commons by Sir Thomas White, Minister of Finance, on April 13th, 1916, *re* zinc or spelter bounty:

Resolved, That it is expedient to authorize the payment out of the Consolidated Revenue Fund of a bounty of two cents per pound on zinc or spelter, containing not more than two per cent. of impurities, produced in Canada from zinc ores mined in Canada provided the standard price of zinc or spelter in London, England, at the time of production is less than £36 19s. 3d. sterling per ton of two thousand two hundred and forty (2,240) pounds, when the bounty payable shall be an amount equal to the difference between such standard price per ton and £36 19s. 3d. per ton. Further provided, that in no event shall bounty be payable when the price received for zinc or spelter by the producer is eight cents or more per pound, and that no bounty shall be payable on zinc or spelter to the producer during the continuation of the war, and in no event on zinc or spelter produced after July 31st, 1917.

This bounty, therefore, would assure a market for zinc concentrates on the basis of 8-cent spelter at least until July 31, 1917, provided the concentrates are smelted in Canada.

PRODUCTION AND CONSUMPTION OF LEAD AND ZINC IN CANADA

Lead

At the present time practically all of the production of pig lead and lead ore in Canada comes from British Columbia. In 1913 very small amounts of pig lead were produced from Ontario and Yukon ores, but of the total of 37,662,703 pounds for that year, 37,636,899 pounds were recovered from British Columbia ores.

The information with regard to the lead deposits of eastern Canada given in this paper shows that a very considerable amount of lead concentrates might be produced in Ontario and Quebec, if there were a lead smelter in eastern Canada which might afford a market. The extent of the demand for pig lead in Canada may be deduced approximately from a consideration of the following figures.[74]

	Lbs.
Total Canada production of pig lead, 1913.....	37,662,703
" " imports of lead,[75] 1913.....	26,229,000
Total supply, 1913	63,891,703
Canadian exports of lead, 1913	329,960
Total demand, 1913	63,561,743

Consequently, in 1913, Canada produced about 59.4 per cent. of her total requirements. The chief consumption of lead is now in eastern Canada, which, in spite of its undeveloped resources in lead ore, produced only a very small quantity of pig lead.

Zinc

The production of zinc ore (concentrates and hand-picked products) in Canada in 1913 was 7,889 tons, which was estimated to contain 7,069,800 pounds of zinc. By far the greater part of this production came from the British Columbia mines, but small amounts were produced from the mines at Notre-Dame-des-Anges, Portneuf county, Quebec. Until 1915, there was no zinc smelter or refinery in Canada, and all the concentrates had to be shipped to the United States or Europe for reduction. Consequently, all the metallic zinc and zinc oxide used in Canadian industry was imported.

During the last three years, experiments on the hydrometallurgy of zinc have been conducted in British Columbia by Mr. French, and by the Consolidated Mining and Smelting Company of Canada at Trail. The result of these investigations is the decision on the part of both companies to erect reduction plants to treat zinc ore on a commercial scale. The new hydrometallurgical plant at Trail is now in process of installation. During the summer of 1915, also, the East

[74] Ann. Rept. Min. Prod. of Canada, Mines Branch, Ottawa, 1913, p. 135, et seq.
[75] Includes, pig, old, scrap lead, sheets, bars, blocks.

Canada Smelting Company have erected an electrolytic zinc reduction plant at Welland, Ontario, and are, at the time of writing, treating small quantities of oxidized zinc ores. Consequently, in the course of another year or so, a considerable amount of Canadian-made zinc should be available for use in home industry.

The Annual Report on the Mineral Production of Canada shows the following figures for 1913:

	Lbs.
Total imports of spelter	10,784,500
Total imports of zinc[16]	9,931,100
Total consumption	20,715,600

The total zinc content of the zinc ores sent to the smelters from the Canadian mines in 1913 amounted to only 7,069,800 pounds, or about 34.2 per cent. of the home consumption. If the new undertakings in the way of the electrolytic reduction of zinc ores prove commercially successful in Canada, there is no reason why they should not develop on a scale sufficient to meet the needs of Canadian industry. At the present time, the chief obstacle in the way of the development and operation of zinc properties in Canada is the lack of home reduction works of large capacity and the necessity of shipping ore into the United States.

DUTIES ON ZINC AND LEAD: CANADA AND UNITED STATES

(*a*) Zinc ore entering the United States: 10 per cent. ad valorem on the contained zinc.

(*b*) Lead ore entering the United States: ¾ cent per pound on the contained lead in excess of 3 per cent.

(*c*) Lead and zinc ores entering Canada: Free.

(*d*) Zinc in blocks, pigs, sheets, zinc dust, old zinc entering the United States: 15 per cent. ad valorem.

(*e*) Lead in pigs, bars, etc., lead dross, lead bullion or base bullion; in sheets, pipe, shot and wire, entering the United States: 25 per cent. ad valorem on the contained lead.

(*f*) Zinc in blocks, pigs, sheets, etc., entering Canada: Previous to the war, this was admitted free of duty. The war tariff imposed a duty of 7½ per cent. ad valorem on these articles.

(*g*) Lead in pigs, bars, sheets, etc., entering Canada: Previous to the war, the duty was 15 per cent. ad valorem. The war tariff imposed an additional 7½ per cent. ad valorem.

CONCLUSION

The descriptions of the deposits in this report have drawn attention to certain areas which deserve a more thorough exploration. The deposits along the north shore of lake Superior merit closer examination, and there seems to be no reason why some of those that have been described should not develop into

[16] Blocks, pigs, sheets.

bodies of commercial importance. The presence of silver in these deposits makes them specially worthy of investigation.

Attention has been drawn to the fact that the calcite-barite-galena veins probably occur in a series of northwesterly striking fault fissures. The natural conclusion is that all such fault fissures would be worthy of exploration. Several of these are shown on Map No. 25c, and it is suggested that careful examinations in the area crossed by these faults might give results of economic importance.

At the present time mining operations for lead and zinc are being conducted at only three localities in Ontario and Quebec. As a market for the products of these mines, there is only the electrolytic zinc refinery at Welland, Ontario, which is at present operating necessarily on a small scale. The lead smelter of the North American Smelting Company at Kingston has been idle for about three years, although reports are in circulation that it may be blown in again in the near future.

It is hoped that the encouragement given to these industries by the Dominion Parliament in the way of bounties, intended to develop finished products so badly needed by Canada and Great Britain for military and other purposes, may result in the establishment of Canadian smelters capable of handling the products that might very readily be furnished to them by Canadian mineral deposits.

INDEX VOL. XXV., PART II

PAGE

Actinolite schists 13
Acts of Parliament 48, 49
Adams, Dr. Frank D. 24
Addington co.
  Zinc. *See* Sheffield tp.
Albemarle zinc mine 42
Allen, E. T. 3
Ance à la Mine. *See* Wright mine.
Anthraxolite 17
Apatite 39
Aplite 13, 45
Ardoch 11
Arkansas, U.S. 42
Assays of zinc and lead ores 6, 11, 14, 15, 17, 35
Baie-St. Paul, Que. 32
Bain, F. H. 40
Balfour tp. 17
Bancroft, Dr. J. A. 12, 13
Barlow, Dr. A. E. 24
Barrie tp. 11, 15, 21-23, 26-30, 34-37
  Map showing veins .....*In pocket.*
Barytes.
  Indicative of low-temperature deposits 2
  Lead mines, notes 37
  Ont., Chats island 22
    Frontenac co. 21, 25, 26
    Hastings co. 23, 28, 29
    L. Superior region 34-36
      McKellar isld. 15
    Leeds co. 28
    Peterborough co. 26-29
    Veins in Eastern, origin 36, 39
      map showing .....*In pocket.*
    Victoria co. 27
  Quebec province 30
Bathurst dist., N.B. 13
Battersea, Ont. 29
Beauce co., Que. 9
Bedford lead mine 25, 37
Bell, Dr. Robt. 8
Biotite 3, 5, 10
Black bay, L. Superior 12, 15, 35
Black river, L. Superior 12
Black river, Ottawa river 32
Blende. *See* Zinc.
Blende lake 34, 35
Bounties 48, 49
Bourke, Ont 16
Bourne, George 42
Bowell tp. 17
Bowie shaft 6
Breccia-conglomerate 14
British Canadian Lead Co. 15
British Columbia 50
Bruce co.
  Zinc. *See* Albemarle z.m.
Buckingham tp., Que 30, 37
Buel, Mr. 28
Burling, L. D. 21, 36, 40

PAGE

Calciferous formation 27
Calcite.
  Lead mines, notes 37
  New Brunswick 13
  New York state 32, 33
  Nova Scotia 33
  Ont., map showing veins .... *In pocket.*
    with lead 16-19, 22-26, 30, 38
    with zinc 11, 45
  Que., with fluorspar 32
    with lead 30
    with zinc 6, 12
Calcspar 25-28, 34, 35
Calumet isld., Ottawa river 5-9
Calumet Metals Co. 6
Campbell, Joseph 22
Campbell lead mine 22, 23
Campbell Bay. *See* Calumet isld.
Canada.
  Lead and zinc statistics 50, 51
    bounties 49
Cape Breton, N.S. *See* Faribault brook.
Carleton Place. *See* Ramsay lead m.
Carter, W. E. H. 8, 9
Cascade lead mine 14
Chalcopyrite.
  New Brunswick 13
  New York state 32
  Ont., with lead 45
    with zinc 8, 10-12, 17
  Que., with zinc 4-6
Chapman, Prof. E. J. 15, 34, 35
Charlevoix co., Que. *See* Baie-St. Paul.
Chats island 21-23
Chaudière falls, Chaudière r. 9
Chelmsford, Ont. 17
Cheticamp Gold Mg. Co. 9
Chibougamou reg., Que. 42
Clark, Howard 33
Coal Hill lead vein 32
Colchester Co., N.S. *See* Smithfield.
Coleman, Dr. A. P. 17
Consolidated Mg. and Smelting Co. ... 50
Copper 6, 8, 12, 35
Copper pyrites. *See* Chalcopyrite.
Creighton tp. 17
Cretaceous system 42
Crown King lead mine 26, 27, 37
Custom duties. *See* Tariffs.

De Kalb, Courtenay 17, 24
Denis, T. C. 4
Diabase 15
Dog lake, Storrington tp. 29
Dolomite 27
Donahue lead vein 29
Dorion lead-zinc mine 35, 36
Dorion tp. 35
Drunken island 15
Duhamel tp., Que. *See* Wright mine.
Duties. *See* Tariffs.

PAGE
Earthquakes 42
East Canada Smelting Co. 51
Ells, Dr. R. W. 36
Elmtree river, Chaleur bay, N.B. 13
Emmons, S. F. 40
England 40, 49
Enterprise, Ont. 48
Enterprise lead mine 15, 35
Epidote 3
E S 79 zinc loc. *See* Gesic z.m.

Fairbank lake 17
Faribault brook, N.S. 9
Fault fissures 40-42, 52
Felix, Ont. *See* Ruel zinc mine.
Fluorine 39
Fluorite 31, 37, 39, 40
Fluorspar 30, 32, 34
Foley, Morris 30
Foley and Co. 25, 28
Fraser, C. F. 33
French, Mr. 50
Frontenac co.
Lead. *See* Barrie tp.
Bedford tp.
Frontenac l.m.
Storrington tp.
Zinc. *See* Long Lake m.
Frontenac lead mine 18-21, 32, 36-38

Gabbro 6, 10, 46
Galena.
New York state 32
Nova Scotia 9, 33
Ontario 10-29, 45
map showing veins ..... *In pocket.*
Quebec 4, 5, 7, 9, 30-32, 42
Galetta lead mine..19, 21, 22, 30, 32, 36-38
Galway tp. *See* Union Creek lead mine.
Garden river 13, 14
Garnets 3, 5, 10
Gaspe pen. 31, 37, 38
Gatineau river, Que. 32
Gesic zinc mine 9
Gillum, Mr. 29
Gneiss 4, 6, 18, 48
Gold.
Ontario 11, 14, 15, 17, 35
Quebec 4, 5, 9, 14
Gorman, James B. 30
Grand Calumet Mg. Co. 6, 7
Granite 6, 46, 48
Granite islet 12
Greywacké 15, 17

Hadley, Prof. 12
Hare, J. 9
Harker, A. 3
Harkness, Capt. John C. 35
Hastings co. *See* Hollandia l.m.
Tudor tp.
Hastings Lead Mg. Co. 28
Haycock, E. B. 16
Haycock lead mine 15, 16
Heavy spar. *See* Barytes.
Hollandia lead mine 23, 24, 32, 37, 39
H R 580 lead loc. 16

PAGE
Hull tp., Que. 30, 37
Hunt, Weston 25
Huronian system 7, 12, 14
Hydrogen sulphide 3

Iddings, Prof. J. P. 25
Illinois, U.S. 31, 38, 40, 42
Indian lake. *See* Frontenac lead mine.
Indian Cove, Que. 31
Ingall, E. D. 16, 34
Inverness co., N.S. *See* Faribault brook.
Iowa, U.S. 38
Iron pyrites. *See* Pyrites.

Jefferson co., N.Y. *See* Redwood.
Johnson, W. A. 9

Kaministikwia river 34
Katherine lead mine 24
Kentucky, U.S. 40, 42
Kesterman, W. 28, 29
Kindle, E. M. 21, 36, 40
Kingdom lead mine. *See* Galetta l. m.
Kingston, Ont. 52
Klock, James 16

Labelle co., Que. 30
Lady Evelyn lake 15, 16
Lake tp. 24, 25, 29, 30
Lake Superior 12, 15, 16, 33-36, 51
Lanark co. *See* Ramsay lead mine.
Lansdowne tp. 28
La Rose Mg. Co. 15
Laurentian system 12, 25
Laurentide Co. 3-5
Lawn shaft 6
Lead.
Bounties on 48, 49
British Columbia production 50
Canadian statistics 50
Deposits, classification of 2
Duty on 51
Mississippi valley 18
New Brunswick 13
New York state 19, 32, 33
Nova Scotia 33
Ontario 10-17, 21-30
map showing veins...*In pocket.*
Price 49
Quebec 5-7, 9, 15, 30-32, 42
Yukon 50
Lead Hills mine. *See* Enterprise l. m.
Leeds co. *See* Lansdowne tp.
Lime-alumina silicates 3, 4, 6, 7, 10
Limerick tp. 30
Limestone 42, 43
Limestone, crystalline.
New York state 32, 33
Ontario..... 11, 18, 21, 22-28, 44, 45, 48
Quebec 4, 6, 30
Lindgren, Dr. Waldemar 1, 3, 11
Little river, Que. 15
Little Gaspe cove 31
Lombard & Co. 28
Long Lake zinc mine 44-47
Long Lake Zinc Co. 44

PAGE
Loughborough tp. 21
Lowe, J. 30

Macfarlane, Thos. 28, 29
McKellar isld. 35
McKinnon lead mine 11, 12
McTavish tp. 15
Madoc tp. 38
Madrid, Spain 42
Magnetite 6, 7, 10
Maps.
Galena-barite-calcite veins, Ont. .... *In pocket.*
Zinc-lead deposits, Ont. ..... *In pocket.*
Marl 15
Marmora tp. 29
Marshay tp. *See* Ruel zinc mine.
Mason, F. H. 9
Mattawa Mg. and Smelting Co. 15
Meteoric waters 38, 39
Methuen tp. 29
Mica schist 11
Millbridge. *See* Katherine lead mine.
Mispickel 9
Mississippi river, Ont. 27
Mississippi river, U.S. 18, 19, 37, 38
Missouri, U.S. 38, 42
Montauban tp., Que. *See* Notre-Dame-des-Anges.
Montreal, Que. 37, 40
Mountain Grove 44
Murphy lead mine 28, 29
Myer Cave 11

New York state.
Lead. *See* Redwood.
Rossie.
Nipigon series 34
North American Smelting Co. 18, 52
North Petite-Nation river, Que. *See* Petite-Nation.
Notre-Dame-des-Anges, Que. 3-6, 50
Nova Scotia.
Lead. *See* Smithfield.
Zinc. *See* Faribault brook.

Olden zinc mine. *See* Long Lake z. m.
Onaping tuff. 17
Ore deposits, origin of 41, 42
Ottawa co., Que. *See* Hull tp.
Ottawa river.
Faults in valley 36-39
Lead-zinc ores. *See* Calumet isld.
Chats isld.
Ozarkian uplift 42

Paipoonge tp. 34
Paleozoic system 42
Palmer, C. 9
Papineau, Hon. L. J. 32
Paresseux rapids 34, 37
Parker & Baker 29
Pegmatite 19, 45
Peridotite 40, 42
Perry, Ont. 11
Perth Road. *See* Frontenac lead mine.
Petite-Nation river, Que. 32

PAGE
Petroleum Oil Trust 15
Pie island 16
Pirsson, Dr. L. V. 41, 42
Poirier lake, Que. 12, 13
Portneuf co., Que. 3-5
Potsdam formation 27, 33
Poupore, W. J. 7
Prue lead mine 17
Pyrites.
New Brunswick 13
New York state 33
Ontario 8, 11, 12-17, 22, 27, 34
Pyrrhotite formed from 3
Quebec 4-6, 9, 10, 13, 14
Pyroxene 3, 10
Pyroxenite 4
Pyrrhotite 4-10, 45

Quartzite 4-6
Quebec prov.
Lead 5, 9, 12, 30-32, 42
Zinc 3-9, 12, 13, 42

Ramsay lead mine 27
Rayside tp. 17
Redwood, N.Y. 33
Reeder, Mrs. 6
Richardson, James, & Sons 44
Richardson zinc mine. *See* Long Lake z. m.
Richmond, George 12
Robertson, James C. 21
Rose, R. R. 17
Rossie lead mines, N. Y. 19, 30, 32, 33, 37
Rossport, Ont.
Zinc. *See* Gesic z. m.
Zenith z. m.
Ruel zinc mine 9, 10
Rush lake. *See* Sahkatawichtah lake.

Sahkatawichtah lake 10
St. Clair lead mine 35
St. Francis, Que. 9
St. Lawrence co., N.Y. 19, 32
St. Pauls bay. *See* Baie-St. Paul.
Saxony 40
Section of mines 44
Selenium 12
Sericite schist 6, 7, 9
Sheffield tp. 48
Shuniah silver mine 34
Silver.
New Brunswick 13
Ontario 11, 14-17, 20, 23, 24, 33-35
Quebec 4-6, 9, 10, 13, 14
Silver-glance 35
Silver lake 34
Slate islands 12
Smelters 50-52
Smith, Dan 16
Smith, W. S. T. 40
Smithfield, N. S. 33
Smyth, C. H. 19, 33
Somerville tp. *See* Crown King lead mine.
Specularite 10
Spelter 49, 51
Sphalerite. *See* Zinc.
Spurr, J. E. 41

PAGE
Steeprock lake 11, 12
Stobie falls 17
Storrington tp. 29
Sudbury dist. 17
Sweeney, Wm. 29

T 30 zinc loc. *See* Zenith z. m.
Tariffs. 51
Tetrault, Pierre 3, 5
Tetrahedrite 10
Thunder bay 16, 34-36
See also Pie island.
Tichborne junction 44
Timiskaming lake.
Silver-lead. *See* Wright mine.
See also Drunken isld.
Trail, B.C. 50
Trout lake, Bowell tp. 17
Tudor tp. 28-30
Twin lakes 16

Union Creek lead mine 26, 37
United States.
Lead and zinc duties 51

Van Ingen, Prof. 39
Vennor, H. G. 29
Vermilion river, L. Huron 17
Victoria co. *See* Crown King lead mine.
Victoria zinc mine 13, 14
Volcanism, notes on 41

PAGE
Wakonichi lake, Que. 42
War, The Great
Zinc bounty not payable during 49
Zinc tariff increase owing to 51
Waters, meteoric 38, 39
W D 252 lead loc. 17
Weedon Mg. Co. 2
Welland 51, 52
Wewegimok lake 16
Whitefish lake, Frontenac co. 11
Willimott, C. W. 7
Winston flag station. *See* Zenith zinc mine.
Wisconsin, U.S. 39
Wolf lake 16
Wright, C. V. *See* Wright silver-lead mine.
Wright silver-lead mine 14, 15

Young, Dr. G. A. 13
Yukon 50

Zenith zinc mine 7-9
Zinc.
Bounty proposed 49
Deposits, classification of 2
Duty on 51
Mississippi valley, U.S. 18
New Brunswick 13
Nova Scotia 9, 33
Ontario..7-9, 11, 12, 16, 26, 33-36, 42, 48
map showing veins.....*In pocket.*
Price 49
Quebec 3, 7-9, 12
Zinc Siding. *See* Zenith zinc mine.

End of Part II.

55

TWENTY-FIFTH ANNUAL REPORT

OF THE

ONTARIO BUREAU OF MINES, 1916,

BEING

VOL. XXV., PART III.

The Geology of Kingston and Vicinity

By

M. B. Baker

APPENDIX I

The Ordovician Limestones of the Kingston Area

By

E. M. Kindle

APPENDIX II

Synopsis of the Common Fossils of the Kingston Area

By

Alice E. Wilson and Kirtley F. Mather

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CONTENTS

THE GEOLOGY OF KINGSTON AND VICINITY.

PAGE

Introduction 1
Age Classification of the Rocks of the Area 2
General 3
Grenville-Laurentian 3
Grenville Series 5
Laurentian 10
Algoman 12
Keweenawan 15
Potsdam 16
Black River 20
Glacial 21
Recent 24
Interesting Exposures 25
  Grenville 25
  Grenville and Laurentian 25
  Laurentian 25
  Algoman 25
  Keweenawan 26
  Paleozoic 26
  Pleistocene 26
Economic Geology 27
  Feldspar 27
  Mica and Phosphate 28
  Lead and Zinc 31
  Barite 33
  Paving and Building Stone 34
  Trap 34
  Lime 34
  Building Stone 35
  Building Brick 36

THE ORDOVICIAN LIMESTONES OF THE KINGSTON AREA.

General Stratigraphic Relations 37
Formational Nomenclature 37
Nomenclature Used 39
Tabular View of Ordovician Stratigraphy in the Kingston Area 40
Description of Formations 40
  Black River Group 40
  Trenton Group 43
Structure 44

SYNOPSIS OF THE COMMON FOSSILS OF THE KINGSTON AREA.

Introduction 45
Synoptic List of Black River Species.. 45
Key to Black River Fossils 49
Synoptic List of Trenton Fossils 53
  Locality List 53
  Faunal List 53
Descriptive Key of Trenton Fossils ... 54
Partial Bibliography of Species Listed 58
Explanation of Plate 1 62
" " " 2 64
" " " 3 66

ILLUSTRATIONS

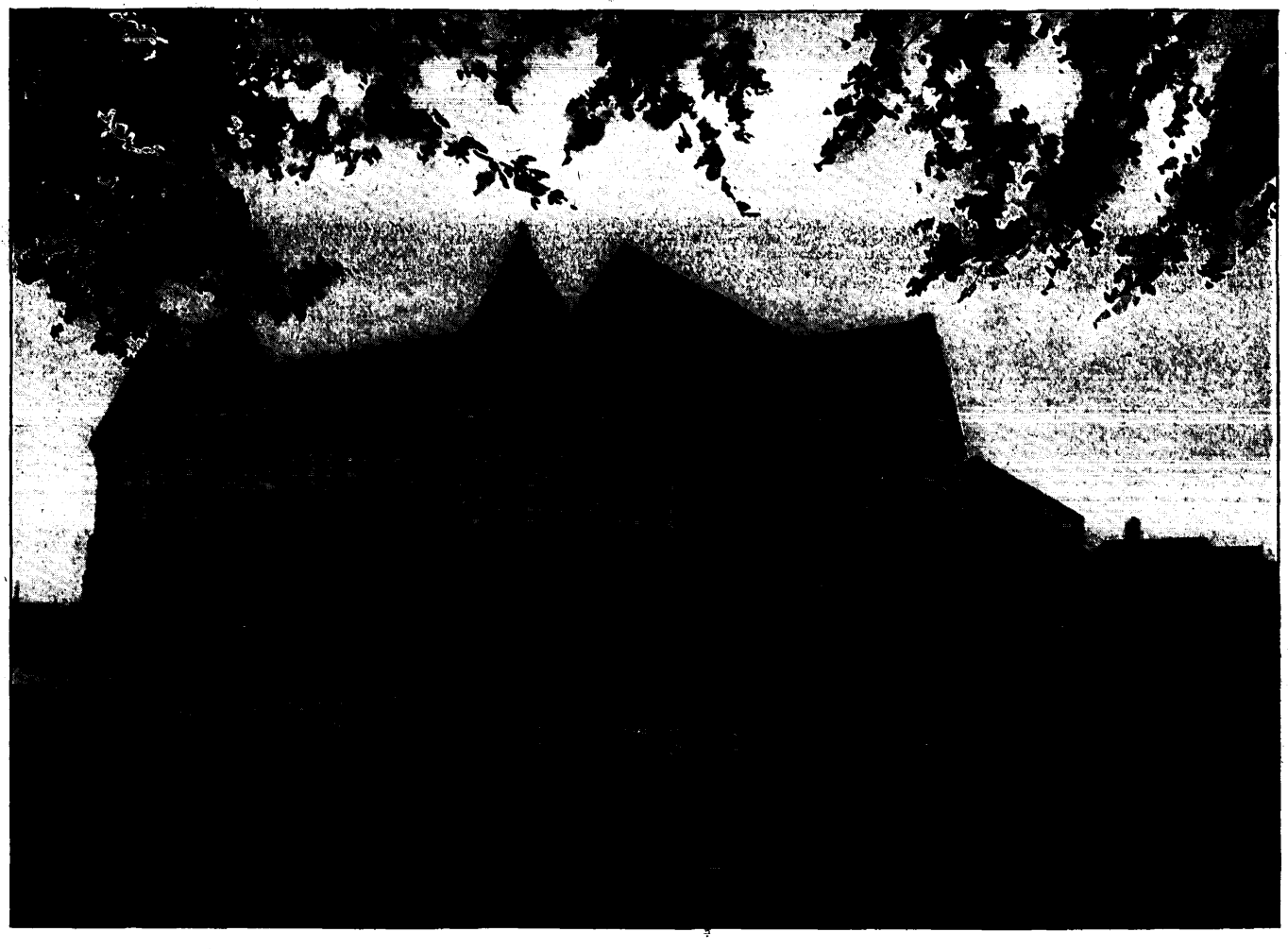
Frontispiece—Geology and Mineralogy Building, Queen's University, Kingston, built of Black River limestone.

PAGE

Fig. 1 —Grenville crystalline limestone, showing original bedding 6
Fig. 2 —Grenville quartzite in perfect conformity with crystalline limestone 6
Fig. 3 —Grenville crystalline limestone with interbedded gneiss, Brewer Mills 7
Fig. 4 —Pseudo-conglomerate of fragments of paragneiss in matrix of Grenville crystalline limestone 8
Fig. 5 —Interbedded Grenville limestone and gneiss 9
Fig. 6 —Graphic pegmatitic intrusion of Laurentian into Grenville crystalline limestone 10
Fig. 6*a*—Glaciated surface of Grenville gneiss with *lit-par-lit* injection of Laurentian granite 11
Fig. 7 —Algoman pegmatite dike which cuts Algoman granite 14
Fig. 8 —Grenville limestone and Algoman pegmatite cut by dike of Keweenawan trap.. 15
Fig. 9 —Close view of glaciated Potsdam conglomerate 16
Fig. 10 —Red ferruginous Potsdam sandstone resting on more steeply dipping buff sandstone 17
Fig. 11 —Contact at Kingston Mills of Black River limestone with Algoman granite 18
Fig. 12 —Cliff-like front of Potsdam sandstone resting on Grenville gneiss floor 19
Fig. 13 —Potsdam cliff, showing "tree-like" concretions 20
Fig. 14 —Grenville gneiss, showing intrusions of Laurentian 21
Fig. 15 —Saugeen clay, composed of interlaminations of calcareous and ferruginous clay 23
Fig. 16 —Polished lead and zinc ore specimen, showing encrustation vein filling 31
Fig. 17 —Polished lead and zinc ore specimen, showing geode filling by encrustation method 32
Fig. 18 —Barite vein in Ordovician limestone 33
Fig. 19 —Church at Cushendall built of Potsdam sandstone relieved with Black River limestone 35
Plate 1. Black River Fossils 63
" 2. " " " 65
" 3. Trenton Fossils 67

MAP

No. 25*e*—South part of Frontenac county, eastern Ontario, geologically coloured, to accompany report of M. B. Baker; scale, 1 mile to 1 inch.



Frontispiece—Geology and Mineralogy building, Queen's University, Kingston, built of Black River limestone.

THE GEOLOGY OF KINGSTON AND VICINITY

By M. B. BAKER

Introduction

Accompanying the Report of the Royal Commission on the Mineral Resources of Ontario (1890) is a geological map, scale 45 miles to the inch, prepared from various Dominion surveys made between 1842 and 1882. This map shows the outline of the Paleozoic against the pre-Cambrian, the latter being divided simply into the Laurentian and Huronian systems. In the vicinity of Kingston the pre-Cambrian area is shown as a narrow neck of land joining two large areas, one to the northwest in Ontario, and the other to the southeast in the state of New York.

In 1901, the Geological Survey of Canada issued a report[1] accompanied by a map, scale two miles to the inch, showing portions of the counties of Frontenac, Renfrew, Lanark and Leeds. This map outlines the Paleozoic and pre-Cambrian areas in very much greater detail, but no attempt was made to sub-divide the pre-Cambrian, which is all depicted in one colour.

During the last decade the pre-Cambrian of this Province has been the subject of particular study. The discovery, in these rocks, of the rich silver deposits around Cobalt, and later the equally rich gold deposits in the Porcupine area having brought the world's greatest geologists to Ontario, the pre-Cambrian rocks naturally came in for the most detailed study and discussion. As a result of all this study we now have definitely accepted relationships among several of the geological groups, and in fact well established ones among all the members of the pre-Cambrian in eastern and northern Ontario.

During the last fifteen years the writer, teaching geology in Queen's University and the School of Mining at Kingston, has been able to take advantage of these groups in the vicinity, so well adapted for instruction of students on geological excursions. Geology is taught to some extent at the Royal Military College, also at Kingston, and the need of a detailed geological map has been sorely felt by all concerned. Moreover, the large productive deposits of mica, feldspar, and other minerals justify some special study, and the writer hopes that the observations made in this report will be of value to prospectors for these and other products.

The actual preparation of a map was carried out by W. R. Rogers, Topographer to the Ontario Bureau of Mines; to him and to the Military Surveys Branch of the Department of Militia and Defence at Ottawa for the use of contoured road maps as well as the detailed maps of the waterways, the thanks of the writer are appreciatively tendered.

The section of this report dealing with the fossiliferous Paleozoic strata has been prepared by Dr. E. M. Kindle under the direction of the Deputy Minister of Mines at Ottawa. At the request of the Bureau of Mines of Ontario the Canadian Geological Survey kindly undertook this section of the report.

The chemical analyses in the report were made by W. K. McNeill, Provincial Assayer.

[1] Geo. Sur. Can., Vol. XII, Pt. I, Iron Ore Deposits along the Kingston and Pembroke Railway, by E. D. Ingall.

During the summer months of 1915 the writer was able to map in considerable detail all the southern part of the county of Frontenac, including the townships of Kingston and Pittsburgh, parts of Portland, Loughborough and Storrington, as well as Howe island, Wolfe and the smaller neighbouring islands. The geology of the northern part of the State of New York, covering the area immediately south of this, was worked out by Messrs. Cushing, Fairchild, Ruedemann and Smythe, and published in 1910.[2] A comparison of the two maps as well as the geology is most interesting, for the structural, topographical, and geological features in general, over the two areas, are identical.

Age Classification of the Rocks of the Area

Below is the classification of the rocks, according to their age relations, used in this report and on the accompanying map. The oldest rocks are at the bottom of the table.

PLEISTOCENE	RECENT		Marl and peat beds, shallow water deposits.
	GLACIAL		Late glacial boulder clay, unsorted. Saugeen laminated clays, sand and fine gravel; all sorted products of glacial till. Boulder clay, unsorted glacial till.
PALEOZOIC	ORDOVICIAN	Trenton Group—	Limestones and interbedded shales.
		Black River Group—	Leray and Lowville—coarse limestones. Pamelia formation—a fine textured limestone. Rideau beds (basal member of Pamelia), shales, sandy limestones and conglomerates.
	CAMBRIAN	Potsdam—	Sandstones.
			GREAT UNCONFORMITY.
PRE-CAMBRIAN	KEWEENAWAN		Trap, diabase and gabbro intrusives.
			INTRUSIVE CONTACT.
	ALGOMAN		Coarse-grained granite and syenite intrusives, with later pegmatites.
			INTRUSIVE CONTACT.
	LAURENTIAN		Grey to pink, medium to fine-grained, granitic gneisses.
			INTRUSIVE CONTACT.
	GRENVILLE		White, coarsely crystalline limestone, with quartzite and rusty-weathering gneisses. Dark green to black gneisses, thoroughly impregnated with minute dikes of Laurentian granite, now also changed to gneiss.

[2] New York State Museum Bulletin, No. 145.

General

The area about Kingston occupies a unique position mineralogically in that it affords a great variety of minerals, many of which are present in such amounts as to be of economic value. Numerous others, of no value economically, are of such perfect development, and of such large dimensions, as to find places in the museums of many institutions.

A list of the most important of these minerals follows:—

Actinolite.	Bytownite.	Hematite.	Pyrrhotite.
Amphibole.	Calcite.	Ilmenite.	Quartz.
Anhydrite.	Celestite.	Labradorite.	Rutile.
Anorthite.	Chalcopyrite.	Milky Quartz.	Scapolite.
Anthraxolite,	Corundum.	Molybdenite.	Sphene.
Apatite.	Dolomite.	Muscovite.	Talc.
Arsenopyrite.	Fluorite.	Nepheline.	Tourmaline.
Barite.	Galena.	Orthoclase.	Wilsonite.
Beryl.	Garnet.	Plagioclase.	Zinc blende.
Biotite.	Gold.	Pyrite.	Zircon.
Bog Iron.	Graphite.	Pyroxene.	

More than half of these minerals have been mined in this area, so that they are not mere accessories requiring microscopic detection.

The area is particularly interesting also in showing the contact of the Paleozoic sediments with the pre-Cambrian floor. The former lie unconformably upon the latter, and at several places the actual contact is excellently shown. It is evident that the northeasterly and southwesterly trend of the ridges and valleys, as well as the peneplane type of topography of the pre-Cambrian as seen to-day, was developed in pre-Cambrian time and not later, as might at first appear probable.

The southwesterly moving ice of the Labradorian ice sheet has been thought by some to have produced the valleys and ridges of corresponding direction, but a study of the area shows a perfect parallelism of structure throughout the whole group. The gneisses and schists strike northeast and southwest, irrespective, as a rule, of their dips. The harder and softer belts of gneiss have their axes in this same direction; the deep valleys and waterways were eroded in this same direction; and even the larger boss-like intrusions of igneous rocks have their longer axes in this general direction. There is little doubt, therefore, that the Labradorian glaciers moved southwesterly as a result of the pre-Cambrian topography already existent, rather than that they produced it. Many remnants or outliers of early Paleozoic beds in the area can be seen as very thin patches that have served to preserve the pre-Cambrian surface, and they all show clearly that the present contour of these early rocks was developed before the Paleozoic sediments were laid on them.

Grenville—Laurentian

The earliest members of the geological record have been the subject of intense study, re-arrangement, and dispute among a large number of investigators. It was not until 1907 that geologists began to agree that the oldest member of the pre-Cambrian series, the Keewatin, was not all igneous in origin as was previously believed. In 1909 the writer, engaged by the Bureau of Mines of Ontario to report on the geology of the Abitibi Lake area,[3] pointed out that certain rusty-weathering

[3] Ont. Bur. Mines, Vol. 18, 1909, Part I, pp. 263-283.

gneisses and schists carrying staurolite, with bands of crystalline limestone and greywacké, were perfectly inter-bedded with the Keewatin iron formation. The writer therefore claimed that much of the Keewatin was of chemical origin.

In 1907 a paper[4] was written on "The Grenville-Hastings Unconformity" by Dr. Willet G. Miller and Cyril W. Knight, in which it was stated that they had found a sedimentary series, which they called the Grenville, resting on a floor of basic lavas, which they called the Keewatin. Subsequent work[5] by these geologists, on the area immediately northwest of the one here under description, confirmed that discovery.

The Keewatin is a term which is therefore now applied, by the Bureau of Mines of Ontario, to the igneous floor on which the sedimentary and chemical deposits lie, and the name Grenville is retained for this sedimentary series. In northwestern Ontario the Keewatin is very abundantly present, and the Grenville is relatively scarce, whereas in southeastern Ontario the Keewatin becomes less and less exposed, while Grenville exposures increase. In the area about Kingston, covered by this report and map, no Keewatin of undoubted identity can be seen. The Grenville is abundantly present and the explanation suggested is that either erosion in this area has not yet exposed the underlying Keewatin, or the Keewatin greenstones, now converted into schists, have been so thoroughly impregnated by the intrusive Laurentian that their igneous character is entirely obliterated.

There are very large areas of green schists throughout southeastern Ontario into which the Laurentian is so thoroughly injected by the so-called *lit-par-lit* process that the original character of the invaded series is entirely destroyed. Many zones or belts of this kind are accompanied by parallel belts of crystalline limestone, quartzite, and rusty schists, so that their Grenville age is undoubted, but equally large belts of green schists, with no recognizable Grenville material whatever, may be thoroughly impregnated Keewatin schists and gneisses of igneous origin. In the hope of proving this, the writer collected material from these green schistose bands, as free from granitic impregnation as possible, and had chemical analyses made to see what information might be gained as regards origin. The results were as follows:—

No.	SiO_2	Al_2O_3	FeO	Fe_2O_3	CaO	MgO	Na_2O	K_2O	CO_2	S	H_2O
1	56.46	16.58	3.39	2.88	1.66	4.12	1.67	9.74	1.04	0.70	1.89
2	59.08	13.90	3.20	3.30	10.68	3.50	1.61	4.23	1.05	0.20	.....

The first sample was taken from typical green gneiss at the south end of Round lake near Battersea. The second sample was taken from a similar green gneiss on Barriefield hill. From all appearance this second gneiss was the same as the first, but the analysis shows it to be quite a different rock. The writer is doubtful as to what reliance may be put upon chemical analyses of highly metamorphosed rocks in determining their origin. So many constituents are re-organized and re-grouped, that it seems only reasonable that many are also removed, and new ones

[4] Idem, Vol. 16, 1907, Part I, p. 221.
[5] Ont. Bur. Mines, Vol. XXII, Part II, 1913.

introduced. If, however, a chemical analysis practically precludes any ordinary sediment, whose other physical and structural characters are such as to be confused with the metamorphic rock under consideration; and if, on the other hand, the same analysis points strongly to an igneous rock whose other characters are compatible with the metamorphic rock under examination, it would then seem justifiable to conclude that the analysis is of real value. The analysis of No. 1 points strongly to a trachyte, or possibly a trachyte porphyry whose phenocrysts are orthoclase.

Under the microscope, this rock is found to be a completely recrystallized gneiss, composed largely of orthoclase, with very little quartz, as the light coloured constituents; and abundant biotite as the sole dark constituent. It shows no plagioclase whatever. While the chemical analysis, therefore, could be that of either an igneous or sedimentary rock, the microscopic analysis rules out the former, for the writer knows of no igneous rock composed of orthoclase and biotite, and free from plagioclase.

The analysis of No. 2 strongly indicates a sedimentary rock, for the high percentage of lime and silica are not attributable to any igneous rock whose other characteristics make it a possibility. Under the microscope this rock is composed just as largely of orthoclase as is No. 1, and with as little quartz as before but the dark mineral in No. 2 is entirely pyroxene; no biotite whatever is to be seen. This rock, also, shows no plagioclase. Of course it must be borne in mind that these rocks may be so completely recrystallized as to bear no mineralogical resemblance to the original rock from which they were formed. For this reason, the writer claims that more stress must be laid on field relationships and structural characters than on either chemical or petrographical analysis.

While, therefore, no Keewatin rocks of undoubted igneous origin have been recognized in the area covered by this report, the writer would still emphasize the possibility that some of the greenish hornblende and biotite gneiss, found in this district, free from bands of crystalline limestone or quartzite, and yet abundantly intruded by small gneissic dikes of Laurentian age, may be Keewatin igneous material, now metamorphosed beyond recognition. Whether this be correct or not, there is no doubt that these gneisses and schists are pre-Laurentian in age, for they are everywhere penetrated by dikes and intrusions of Laurentian.

Grenville Series

The Grenville consists largely of white crystalline limestone, quartzites, rusty-weathering gneisses, and dark micaceous and hornblendic schists. These schists have already been described as being possibly Keewatin igneous rocks, but they are also mentioned here as there is no proof that they are not Grenville sediments.

The limestones are as a rule coarsely crystalline, the individual grains being commonly about the size of peas. They are rather pure as a whole, but in many places they contain flake graphite, phlogophite, hematite, chondrodite, vesuvianite, diopside, quartz, and other minerals. Their softer character has rendered them more susceptible to erosion than the accompanying rocks, so that they occupy, in general, the basins of the various lakes in the area, and also the valley depressions of the northeast and southwest drainage channels. This is a very pronounced feature of the area and is well brought out in the accompanying map. The section which accompanies the map, cutting across the strike of the rocks, shows rather

well the depressed portions of Grenville limestone, due to more rapid erosion, as compared with the more resistant portions of Laurentian, Algoman or Grenville gneisses.

The original bedding of the limestones can still be seen in many places, and shows the series to be standing at high angles, from 40° to 65° (Fig. 1). The

Fig. 1—Grenville crystalline limestone, showing original bedding preserved. Lot 2, con. X, Portland township.

Fig. 2—Grenville quartzite in perfect conformity with crystalline limestone, showing original bedding of both and the superior hardness of quartzite. Lot 2, con. X, Portland township.

constancy of strike in this series, and the pronounced isoclinal dip of most cross-sections have led to numerous discussions as to the thickness of these sedimentary beds of Grenville age. The writer attempted to work out the structure of the crystalline belts, but found the dips so variable that he was unable to accomplish it satisfactorily. It would appear, however, that the repeated belts of gneiss, crystalline limestone and quartzite, as shown on the accompanying map, are due to isoclinal folding of the Grenville and Keewatin series. Even this conception means that each of these belts would represent a series of great thickness, tilted up at a high angle.

Fig. 3—Grenville crystalline limestone with interbedded rusty-weathering gneiss in perfect conformity, Brewer Mills.

The Grenville quartzite is a compact greenish to white rock, often showing the distinct banding or bedding of the original sandstone from which it was formed (Fig. 2). The masses are so dense and hard that they form very prominent features in the landscape, usually standing up as distinct ridges with their long axes running northeast and southwest, while softer members of the Grenville series occur in parallel hollows and valleys. In many places the quartzite is in contact with the crystalline limestone, and small bands of quartzite from two to ten inches thick are interlaminated with the limestone.

Great belts or zones of rusty-weathering gneiss, and also of black micaceous

and hornblendic gneisses, are to be found throughout the area under consideration. The rusty colouring is due to the weathering of pyrite, which so many of these gneisses contain. The outstanding feature of this group is its prominent platy bedding, in addition to the gneissoid or schistose texture, and it is significant that these planes correspond so perfectly in direction to both strike and dip.

The rusty-weathering gneisses and schists are in many places interbanded with crystalline limestone, and every warp or bend in the one rock is accompanied by a parallel bend in the other. A good cross-section of such a series is shown at Brewer Mills in a ridge through which the road cuts (Fig. 3). Samples collected from these rusty gneisses at this point gave the following analyses:

SiO_2	Al_2O_3	FeO	Fe_2O_3	aO	MgO	K_2O	Na_2O	CO_2	H_2O	C	S
45.14	11.29	0.33	2.40	20.42	3.26	3.86	2.90	10.08	0.50	0	trace
48.34	12.71	0.28	5.43	19.85	1.66	2.51	2.64	2.90	1.09	2.45	0.37

Fig. 4—Pseudo-conglomerate of rusty-weathering fragments of paragneiss in a matrix of Grenville crystalline limestone. Lot 8, con. VI, Pittsburgh township.

The writer has already stated his doubt as to the value of chemical analyses of highly metamorphosed rocks. Taken in conjunction with field relationship, distribution, and geological form of occurrence, rock analyses may, however, offer evidence of a reliable and confirmatory value. From the above field relations and the analyses obtained it is probable that these rusty-weathering gneisses represent psammitic sediments, which were originally present as beds of impure sediment with the limestone, and suffered metamorphism along with it to produce the gneissic characters now manifested.

Of very frequent occurrence is a pseudo-conglomerate, composed of fragments of rusty-weathering gneiss in a matrix of crystalline limestone. This might be

mistaken as evidence of an unconformity, showing the gneiss to be an older series. A close examination of the inclusions, however, shows that they are fragments of beds of paragneisses, which were mashed up with the limestones during their metamorphism. The gneisses being harder, fractured; while the softer limestone flowed around the pieces of gneiss, and these were moved like phenocrysts in a porphyry, so that they often show a flow-like alignment (Fig. 4).

The only other explanation is that they represent apophyses or dike-like offshoots from the intrusive Laurentian, which found their way into the Grenville limestone, and were later metamorphosed with it, assuming a gneissoid structure. There is no evidence, however, of contact metamorphism with its development of

Fig. 5—Interbedded Grenville limestone and gneiss, slightly deformed by Algoman granite intrusion seen below the tree in illustration. Lot 17, con. IX, Storrington township.

contact minerals, nor does the chemical analysis appear to be that of an igneous rock. Later Algoman granitic intrusions into the Grenville will be shown to have produced quite different effects. The writer therefore believes that these rusty gneisses are true sedimentary gneisses, "paragneisses," the result of metamorphism of psammitic sediments which originally accompanied the limestone (Fig. 5).

Outside of the limestone belts, but in perfect parallelism with them, is a great series of dark-coloured gneisses with the outstanding platy structure already mentioned. These gneisses, believed to be metamorphic sediments, also are placed with the Grenville, but as already explained, the writer is unable to prove that they are not of igneous origin. Their platy bedding, in addition to their gneissic structure, is their outstanding feature. This general structure makes them comparable with the sedimentary Moine series of the northwest Highlands of

Scotland, and the similarity is most striking. The platy character of these rocks is so well developed that splendid slabs can be obtained for paving of yards and walk-ways in exactly the same manner as the Moine material is used in Scotland. The writer therefore believes that these bands are also sedimentary rocks converted by load metamorphism into a series of schists and gneisses, whose platy structure still corresponds with the bedded structure of the original rocks.

Laurentian

The Laurentian has been defined by the International Committee on nomenclature as the great masses of gneissic granite which invade the Grenville series[*] and nothing younger. It is essential that this point be insisted on because

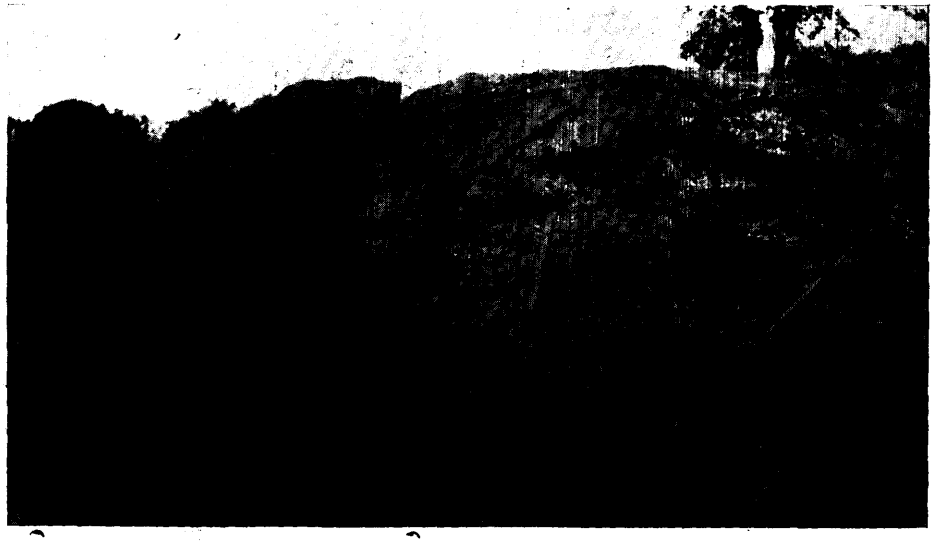


Fig. 6—Graphic pegmatitic intrusion of Laurentian into Grenville crystalline limestone, yielding the so-called *Eozoon canadense* of the latter series. East shore of Collins lake.

another series of pink granites, often somewhat gneissic, invades the Grenville and later formations, and it is only by stratigraphic field examination that the two can be definitely distinguished.

The Laurentian is granitic for the most part, but also has syenitic phases. It is medium to fine grained, pink to greyish in colour, and always gneissic in structure. A small amount of mica (biotite) is usually present, and this brings out prominently the gneissic structure on weathered surfaces. The writer was able to find but two belts of Laurentian rocks that were sufficiently large and free from included Grenville material to show their real character. One of these is shown on the map one mile north of Hartington station on the Canadian Pacific railway. The other is seen as a long belt extending northeasterly from Washburn on the east side of the Rideau canal. A chemical analysis of this latter rock, given

[*] Jour. Geol., Vol. 15, 1907, p. 216.

below, shows at once that it is a typical granite converted into gneiss by metamorphism:

SiO_2	Al_2O_3	FeO	Fe_2O_3	CaO	MgO	Na_2O	K_2O	CO_2	S	H_2O
64.45	14.11	0.10	8.96	trace	0.19	1.62	7.20	0.54	trace	3.07

While large boss-like masses of Laurentian are rare in the vicinity of Kingston, there is nevertheless much Laurentian showing in the form of minute dikes, finding their way up through the earlier Grenville, and possibly Keewatin series. These intrusions took the lines of least resistance. They are therefore abundant as elongated lens-like bands whose longer axes correspond to the gneissoid and

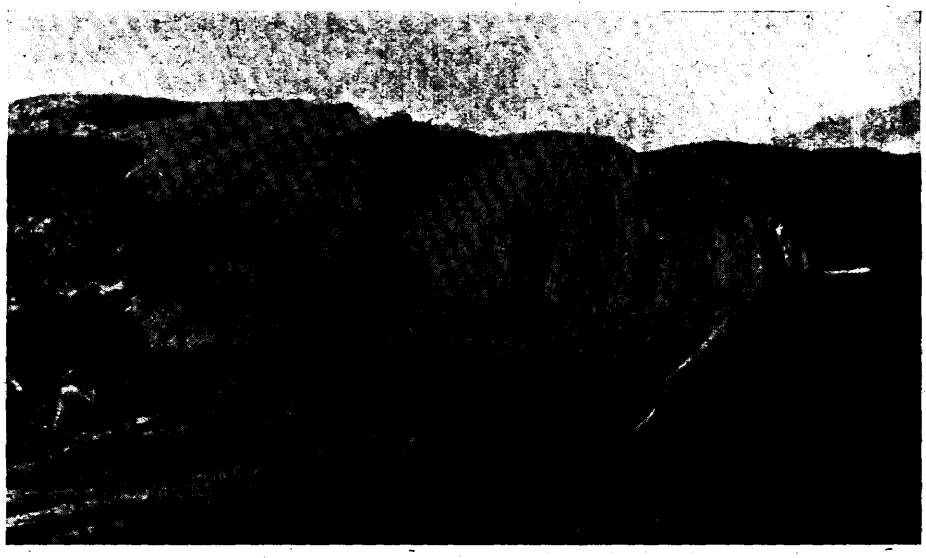


Fig. 6a—Glaciated surface of Grenville gneiss with *lit-par-lit* injection of Laurentian granite. Lot 13, con. XI, Portland township.

bedded direction of the earlier sediments (Fig 6a). There is no evidence in this area that the intrusions of Laurentian deformed the earlier series of rocks. There is no deformation or crushing, but the action seems, rather, to have been one of slow stoping and infusion. Whether there has been any great amount of assimilation of the country rocks by the intrusive Laurentian, it will probably never be possible to prove, but it is difficult to see how the necessary room for these intrusions could have been made in any other way than by slow assimilation, since, as already mentioned, there is no evidence at hand that dynamic forces were applied to shove existing barriers aside.

The Laurentian therefore in this area is present in the form of innumerable little dikes, some of which cut the earlier rocks at various angles to their bedding and gneissic structure, though the bulk of them follow the bedding planes perfectly, and in such profusion that the result is a banded or ribboned series, composed of alternate strips of Laurentian and Grenville or Keewatin, making the most perfect *lit-par-lit* structures one could find (Figs. 6a and 14).

These minute dikes of Laurentian are so numerous that it is difficult to determine which formation predominates. It is therefore scarcely possible to decide whether such areas should be mapped as Grenville-Keewatin or Laurentian. A mixed symbol has therefore been used for them. In many places the alternate bands of Grenville or Keewatin schists and Laurentian gneiss are not over half an inch thick, and are repeated so often as to produce a most striking result. Both the little dikes and the alternate beds of Grenville have been rendered further gneissoid in perfectly parallel position, so that the resulting series is not only banded but is gneissic in the same elongated direction. So many of the small Laurentian dikes jog across the Grenville from layer to layer, as to preclude any idea of their being contemporaneous in age with those schists. This jogging across of the little dikes, from layer to layer, has produced a mosaic-like structure, and has therefore been called by Cushing "the mosaic type of intrusion" to distinguish it from the "leaf type" already described. These intrusions, which impregnate the Keewatin and Grenville, but nothing younger, are called Laurentian.

Algoman

In their work[7] in southeastern Ontario, Miller and Knight have succeeded in demonstrating that a series of intrusive granites and syenites, the Algoman, cuts the Hastings group which, they have further considered, is the parallel of the Timiskaming series. The writer cannot prove that the igneous masses which he has placed in the Algoman are post-Timiskaming. It can be readily proved, however, that they are later than the Laurentian; and since they correspond in every respect with post-Timiskaming intrusives of the area lying immediately to the northwest, as worked out by Miller and Knight, he believes them to be identical in age; i.e., Algoman.

Exactly similar occurrences are found in the Thousand Island region and are described by Cushing in his report on that area.[8] Regarding these rocks Cushing says,

> This [Picton granite] is the latest, most extensive, most interesting, and most important of the intrusives of the region; it is named from Picton island, where it is most extensively quarried.....across the border in Canada it seems to have large extent, though it has not yet been differentiated from the Laurentian in mapping. If, however, we are correct in correlating the granite at Kingston with this rock, a batholith of considerable extent is implied. The general rock is rather a bright red granite of quite coarse grain. It varies much in this respect, however, and much of the border rock is of much finer grain. Red feldspar constitute 75% or more of the rock. Considerable quartz is usually present and is frequently characterized by a slightly bluish cast, which makes a helpful diagnostic feature of the rock. Hornblende and biotite are sufficiently abundant to show prominent black spots in the otherwise red rock. In all likelihood the rock can be carried across on the Canadian islands to the mainland and thence west to Kingston, but until this has been done some reserve must be felt in making the correlation.

A casual examination of these later granites, syenites, and their accompanying dikes, causes one to hesitate to distinguish them from the typical Laurentian members which they so closely resemble. Where the Timiskaming series is present the age of these granites and syenites is of course readily determined, for if they cut or include fragments of the Timiskaming, they must be Algoman, but if they do not, they may be Laurentian. But even where no Timiskaming is present by which to

[7] Ont. Bureau Mines, Vol. 22, 1913, Part II, p. 132.
[8] New York State Museum Bulletin, 145.

fix the age of the Algoman, a close examination of it brings out the following characteristics:—It is a coarser grained rock than the Laurentian, composed of pink orthoclase and microcline feldspars, with bluish to milky coloured quartz instead of the clear, glassy, colourless quartz. Biotite and hornblende are often present, but occur in larger grains and are not so abundant as in the Laurentian gneisses. The rocks are distinctly redder in general appearance, noticeably fresher and undecomposed. They are very much less gneissoid than the Laurentian, in fact, most of the granites and syenites of Algoman age show no gneissic structures at all, and are typical, medium to coarse grained, plutonic crystallizations.

A gneissic structure is, however, often shown fairly well developed along the margin of the mass, but even here the gneissic structure is brought out rather by the drawn-out character or alignment of the dark minerals, than by the crushed and dynamically squeezed appearance of the rock. This alignment of dark constituents in the Algoman borders appears to be more probably due to a flow structure produced while the mass was still potentially liquid by a rubbing or flow along its margin, than to true gneissosity due to subsequent dynamic forces. From these main differences it is possible to distinguish with a great degree of certainty between Laurentian gneisses and the much later Algoman granites and syenites, even when gneissic in structure.

In the description of the Laurentian given above emphasis is laid on the amount of *lit-par-lit* intrusion with the Grenville gneiss, yielding characteristic banding or ribbon-like rocks. While it has not been possible to find the Algoman cutting isolated masses of Laurentian, nevertheless, splendid and numerous examples of large blocks of the *lit-par-lit* combination are found as isolated, free-floating inclusions, in bodies of Algoman granite. Dikes or apophyses from Algoman masses extend across the contact, and far into the surrounding country rock, crossing for long distances the gneissoid structure, as well as the *lit-par-lit* banding.

As a final phase of the Algoman intrusion, and after it had cooled sufficiently to be jointed and fractured, came a series of pegmatite dikes, which showed a considerable tendency to differentiate (Fig. 7), so much so, that large economic deposits of feldspar and of quartz have resulted in many cases. This feldspar is pink in colour and is largely microcline; at other times it is an intimate mixture of orthoclase and microcline, with microperthitic texture. The quartz of the pegmatites is also in sufficiently large masses to be mined separately, and used in the manufacture of ferro-silicon, silicon bronze, and in other industries requiring silica. Further consideration of this will be found in the economic section of this report.

Where these Algoman pegmatite dikes cut Grenville or Keewatin gneisses, or mixed Grenville and Laurentian gneisses, they form these coarse-textured, pink-coloured dikes whose feldspar is rich in potash, running usually thirteen per cent. Where these dikes, on the contrary, cut Grenville crystalline limestone, they yield white or bleached-looking pegmatites, composed of pale, white feldspars carrying six per cent. of potash and three per cent. of soda. In these white pegmatites, moreover, there is not the same tendency to differentiation as in the pink ones, and in no single case was the feldspar sufficiently free from quartz intergrowth to yield merchantable feldspar. Contemporaneous crystallization seems to have been the rule in these dikes, and this therefore helps to distinguish them from Laurentian

dikes cutting the same series. They frequently possess a graphic texture, which is both megascopic and microscopic, for even fragments of apparently clear white feldspar, when examined under the microscope, show abundant micro-pegmatitic intergrowths of quartz with oligoclase.

The quartz that is not in graphic intergrowth with the feldspar also shows a tendency to be diffusely scattered throughout the dike, and not segregated as in the case of the pink-coloured pegmatites, which cut the non-calcareous country rocks. In no case could a pink dike be found cutting the crystalline limestone.

Fig. 7—Algoman pegmatite dike which cuts Algoman granite. Washburn, Rideau canal.

Dr. Cushing in his report on the Thousand Islands, records the same effects where granitic dikes cut crystalline limestone. He added the very interesting information that he decoloured pink feldspars by heating them over an ordinary Bunsen burner in the presence of limestone. His account is as follows:[9]

A sample of finely crushed and sorted red granite was ignited by us for three hours over a Bunsen flame in a platinum crucible. The portion in close contact with the sides and bottom became white, while the bulk of the material, in more central position, and hence less strongly heated, retained its red colour. This we take to indicate, that with sufficiently high temperature, even in feldspar the red colour will disappear, and that the presence in rocks of alkaline feldspar, coloured red by ferric oxide, shows that, under the conditions of congelation, the temperature was not sufficiently high to bring about this colour change. We then mixed a small quantity of powdered limestone with another charge of the crushed granite, and ignited in the same crucible over the same burner for the same time. Not only was the feldspar of the entire charge bleached, but the bleaching seemed complete at

[9] New York State Bulletin, No. 145, p. 179.

the end of one hour. Finally we ignited a third charge, in which a very thin coating of limestone was spread over the top, but not mixed with the granite as in the previous case, and here again the bleaching was prompt and absolute. It is not intended to imply that the cause of the bleaching was the same in both cases, but only that, in the presence of lime, decoloration took place more readily, and at a lower temperature; precisely what field relations had indicated for granite in place.

There is usually a considerable development of contact metamorphic minerals in such associations, the chief of these being scapolite, apatite, diopside with lesser amounts of vesuvianite, graphite, phlogopite, fluorite, chondrodite and other minerals. Some of these are of economic value and will be discussed in the economic section of this report.

Keweenawan

The youngest of the pre-Cambrian rocks in the vicinity of Kingston is a group of diabases, traps and gabbro intrusives. These cut the Algoman as well as

Fig. 8—Grenville crystalline limestone cut by Algoman pegmatite and both of these cut by a vertical dike of Keweenawan trap. Lot 5, con. VI, Storrington township.

all earlier rocks (Fig. 8). In other parts of Ontario a thick series of sediments, which lie uncomforably on the Algoman, and which are known as Animikie in age, are cut by a similar set of basic dikes and sills, and their age is therefore fixed. Since, in this area no Animikie rocks are to be found, it can only be said that these later dikes are post-Algoman, but as was the case in considering the Algoman, the perfect similarity of material and structure seems to justify the correlation of these basic intrusives with the proven Keweenawan of other areas. The only alternative is to introduce other periods of igneous activity than those generally recognized throughout the pre-Cambrian rocks of Ontario, and this is much less justifiable than to correlate them with the already well known and established periods.

These dikes and intrusives vary from fine-grained traps to coarse gabbro-like masses. A microscopic examination of them shows that they are augite diabases, whether fine or coarse grained. They show the most beautiful ophitic textures, with lath-like blades and crystals of basic plagioclase, cutting into and through

large honey-coloured crystals of augite. Their texture is therefore identically like that of the other well-known Keweenawan rocks of northern Ontario, and, moreover, they carry traces of nickel, a further strong evidence from the standpoint of consanguinity. They are remarkably fresh and undecomposed, and are therefore believed to be the youngest of the pre-Cambrian rocks in this area.

Potsdam

The intrusions of the Keweenawan period closed the pre-Cambrian in this as in other parts of Ontario. A long period of weathering and erosion followed during which the Keweenawan, and all earlier rocks, were subjected to processes of denudation to such an extent as to produce practically the same topography as we find to-day over the whole of the pre-Cambrian. This must have

Fig. 9—Close view of Potsdam conglomerate, glaciated and showing remarkably little weathering since glacial times. Lot 7, con. V, Loughborough township.

been a very long period of erosion, for the country was almost base leveled. This feature has been well preserved by the earliest sediments of the Paleozoic seas; and small outliers of these sediments, which remain to-day, show the underlying pre-Cambrian floor to have exactly the same contour and general character as that of the exposed areas. Glaciation, of course, eroded both the pre-Cambrian and the later rocks, and has served merely to freshen the existing topography of the country, but has not produced it.

Overlying this pre-Cambrian floor we find first the Potsdam series. In most places there is a basal conglomerate up to four feet thick, composed of well-rounded, water-worn pebbles and boulders of granite, quartzite, trap or other hard resistant igneous rocks. One striking feature of all these basal conglomerates, is the absence of any of the softer rocks. Scarcely any pebbles or boulders of gneiss, schists, or crystalline limestone are to be seen, but only the harder rocks, as stated above.

It has been pointed out that the erosion valleys of pre-Cambrian times were for the most part made in Grenville belts, with the harder gneisses and igneous rocks standing as ridges, and forming watersheds. It is natural, therefore, that the gravel and boulders of erosion should be scattered along the Grenville valley bottoms. This seems to explain the rather striking fact, that the Potsdam basal conglomerate, is very much better developed over Grenville areas than anywhere else, and it also serves to account for the abnormally large percentage of Grenville quartzite fragments found in the Potsdam conglomerate. The extremely well-rounded, water-worn character of the boulders is thus readily explained, for they represent the products of profound erosion and abrasion (Fig. 9).

Many other layers of conglomerate up to three feet thick occur within the Potsdam accumulation itself, in addition to those at the base. There are no

Fig. 10—Red ferruginous Potsdam sandstone resting on more steeply dipping buff sandstone. Lot 10, con. VI, Pittsburgh township.

transition phases, but abrupt changes from well-sorted, even-grained sand, to coarse cobble beds always nine-tenths quartzite cobbles. This is most interesting and not easily explained. In many places well-sorted sandstone, at least ten feet thick, lies below such conglomerate layers, with no transition phases either above or below; this abruptness of contact may possibly indicate freshet accumulations.

The Potsdam, as a rule, is a rather even-grained uniform sandstone, with a total thickness in this area of sixty-five feet. There appear to be two members in the series; a lower group of buff to white sandstone with siliceous cement, which layer appears to be about twenty feet thick, and an upper and much thicker group of red sandstones, quite rich in iron oxide as a cement material. A transition series of interbanded red and white sandstone layers is found in many places, from the lower to the higher series.

A small but interesting exposure of these two sandstones is shown on the so-called Cuddy island, part of lot 10, concession VI, township of Pittsburgh. Here

the upper red standstones dip to the northeast at 8°, and rest with a slight disconformity on the lower white to buff sandstone, which dips at 16° to the north (Fig. 10). There is a thin layer of pebbly conglomerate marking the junction of the two. The pebbles are pre-Cambrian fragments and not the lower standstone. This would show a short break in the deposition during which pre-Cambrian material was again brought on to the area. This is the best evidence seen by the writer, that these two sandstones belong to different groups, sufficiently distinct in age to be noted.

The lower light-coloured sandstones are not always present beneath the red ones, because they conformed to the surface of the pre-Cambrian floor on which they were deposited; moreover they were evidently laid in shallow water, as indicated by the crossed bedding, and the abundance of true ripple and wave

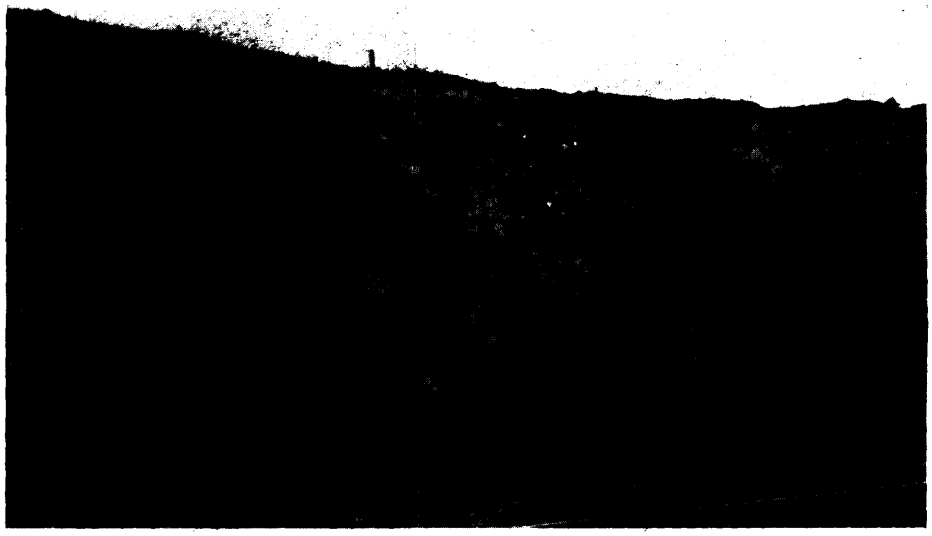


Fig. 11—Contact at Kingston Mills of Black River limestone (above) with Algoman granite (below).

marks. It was pointed out above that the pre-Cambrian was an area of low ridges, with hummocky topography in general and with broad-bottomed, relatively shallow basins and valleys. The extremes of local relief would seldom be over 150 feet. Even this was quite sufficient to cause many island-like areas of pre-Cambrian to remain above the Cambrian sea; thus the valleys and basins only, would have this earliest white to buff sandstone laid in them. The upper red sandstone would later cover these, but in many other places would rest directly on the island-like pre-Cambrian areas just mentioned. Even these later Potsdam seas did not submerge all these islands, for in many places the still higher Ordovician limestones rest directly on the pre-Cambrian, with splendid basal conglomerates marking the contact. In most cases, however, these later limestones rest conformably on the upper red sandstones of Potsdam age.

The margins of the limestone as they rest on the sandstones, and of the sandstones as they rest on the pre-Cambrian, are almost always cliff-like, fifteen feet or more in height. This is no doubt to be accounted for by the bedding as well as

the jointing of the sediments, which would tend to weather and drop away in blocks; rather than by slow gradual abrasion, which would produce a tapering or lens-like contact. This latter condition prevails where the recent glaciation has scoured a contact between either of these sedimentary rocks and its underlying floor (Fig. 11). Where the margin is not glacially eroded it is cliff-like (Fig. 12).

In some of these cliffs of sandstone most peculiar concretion-like structures are to be found. They have been examined and described by geologists from various parts of the world, but everyone is at a loss to know their exact character, or the explanation of their structure. Similar structures are reported by Cushing, Fairchild and others in the Potsdam sandstones of New York State. The writer found similar structures in two other cliffs, namely, lots 21 and 22, concession X, of Storrington, on the long sandstone tongue, along which the

Fig. 12—Cliff-like front of Potsdam sandstone with conglomerate at base, resting on Grenville gneiss floor. Lot 5, con. VI, Storrington township.

road runs, at the north side of Dog lake. The most famous location, however, and the best exposure, is the sandstone quarry known as Blake's quarry, lot 9, concession V, Pittsburgh township, on the Rideau canal. In a cliff of sandstone at this quarry are long cylindrical structures which have been called "fossil trees, fossil telegraph poles, etc." (Fig. 13).

In cross-section these show a ringed concentric structure, duplicating perfectly the annular rings of certain trees. The materials, and binding cement of these structures are exactly like that of their surroundings, and this tends to argue against their being concretions, whose character is normally different in composition from the ground-mass in which they are found. For example, iron-stone concretions in shales, calcareous concretions in shales or in clays, cherty concretions in chalk, etc. These cylinders are of various diameters from 14 inches to 21 feet, and are separated from the surrounding rock by a sharp cylindrical joint, and the structural features do not cross this joint. Moreover, the arrangement of the

sands that make up the cylinders is in concentric rings, like the annular layers of a tree trunk. The writer is, therefore, strongly of the opinion that they are not concretions, as has been usually claimed, but are structural accumulations, formed contemporaneously with their surroundings, and represent sand laid in whirlpools or other eddying water which gave them their circular form and common composition with their surroundings.

The writer has correlated this sandstone with the Potsdam, because it is undoubtedly a continuation of the fossiliferous sandstones, found across the St. Lawrence river in the State of New York and shown to be Potsdam by Cushing, Fairchild and others.[10]

Fig. 13—Potsdam cliff, showing "tree-like" concretions.
Lot 9, con. V, Pittsburgh township.

Black River

The Ordovician limestones overlie the Potsdam sandstone with perfect conformity, but frequently rest directly on the pre-Cambrian. They are very fossiliferous, in marked contrast to the Potsdam and worthy of special notice. The cooperation of the Geological Survey of Canada was, as mentioned above, solicited for the study of this group and its paleontology. The Deputy Minister of Mines, R. G. McConnell, kindly nominated E. M. Kindle for this work. His report, together with that of A. E. Wilson and K. F. Mather, appear as Appendices I and II.

From middle Paleozoic times to the opening of the Pleistocene, this area was out of water, although in those areas to the southwest the various members of the Paleozoic series, occur in perfect order from the Trenton to the Middle Carboniferous.

[10] New York State Bulletin No. 145.

Glacial

At the close of this long period of time there were three relatively short stages of geological activity which bring us to the present. The first of these was the burial of all eastern Ontario, including this area, under the Labradorian ice sheets. There is now ample evidence that there was more than one advance and retreat of the ice, with inter-glacial periods of considerable duration, but for the present purpose these are all included under the first epoch.

The second geological event was a submergence of a portion of eastern Ontario, including a large part of the area now under description. This occurred towards the close of the Pleistocene, that is, during the retreat of the ice front.

The third and last episode brings us to the present. After the retreat of the ice, the area slowly rose again bringing the Thousand Island region to its present altitude, and ponding back the waters to form our present lake Ontario, whose outlet is 246 feet above tide water. This has ushered in the present period of land denudation, weathering, and atmospheric attack, exactly like that which preceded the Labradorian ice advance.

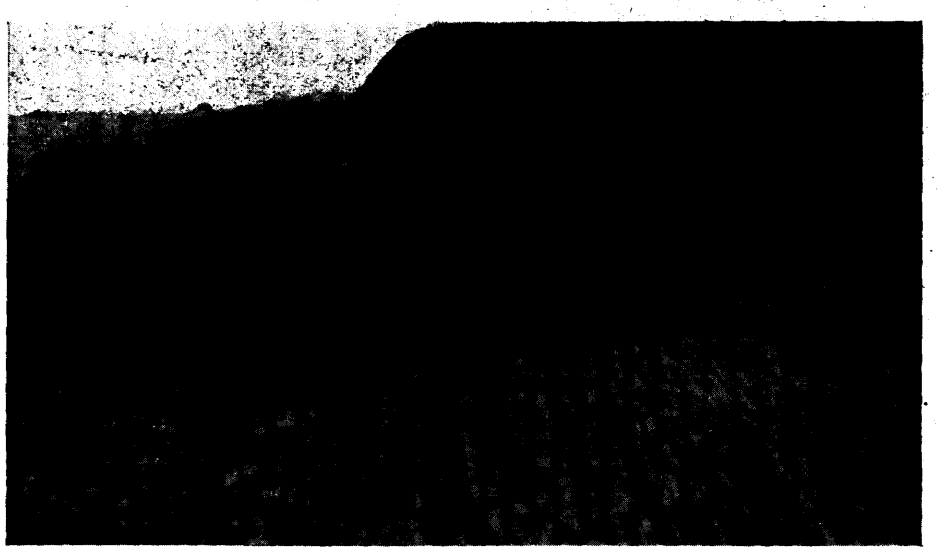


Fig. 14—Grenville gneiss, showing prominent *lit-par-lit* intrusions of Laurentian. Lot 2, con. III, Pittsburgh township.

Discussing the first of these three events, evidence of a great glacial movement is to be found everywhere from the Labradorian area east of Hudson bay, in a southwesterly direction, into the northern part of the United States. Great deposits of till, made up of indiscriminate mixtures of clay, sand, silt, gravel and boulders are found overlying well-polished, smoothened, striated, and gouged rock surfaces. Every trace of decay or weathered rock has been scraped off, and a perfectly fresh surface presented to the renewal of weathering processes (Fig. 14) .

There is no actual means of telling how deep was the layer of residual soil which covered the rocks of this area before the advance of the Labradorian sheet, but from the fact that these rocks were exposed from Trenton times onward, we might

conclude that the residual soil was very deep, and it is extremely doubtful if the pre-Cambrian of this district was exposed anywhere till bared by the Labradorian ice sheets. The many outliers of Paleozoic sediments strongly suggest that they covered all this portion of Ontario previous to the advance of the ice. The writer has described the structure of the pre-Cambrian, and accounted for its topography as being the result of erosion on a series of harder and softer belts of intrusives with schists, gneisses and crystalline limestones. The whole structure was developed northeast and southwest, into ridges and valleys due to differential hardness. The ice movement was, therefore, forced to take this general direction from the Labradorian highlands. When it met the Paleozoic sedimentary area its direction of flow was already well established, and we have splendid evidence of this in the direction of glacial striation and gouges on otherwise flat-lying, smooth sedimentary rocks. It is most strikingly brought out by a glance at the map accompanying this report. The tongues or peninsulas of sediments, as they project northeast from the general area, are most evident, and show that they occupied the pre-Cambrian hollows. Corresponding projections of the pre-Cambrian in a suthwesterly direction, mark the axes of ridges between depressions filled with Paleozoic sediments.

Overlying this rock surface we find a variable thickness of unconsolidated material. Three horizons are recognizable, and mark broadly the three episodes spoken of above. The deposits of the first and oldest, and, therefore, lowest, are beds of glacial drift or till, composed of calcareous clay, for the most part, but mixed in many places with sand, gravel or boulders. This represents moraine deposited by the glaciers with little or no sorting. These accumulations are found only at higher levels, for all the accumulations in lower areas have been covered by later deposits to be presently described. Almost everyone in Canada is familiar with the typical glacial drift, and particularly with the boulders or hard-heads which, in some localities, have to be picked off our agricultural areas. In the vicinity of Kingston there is the usual collection of rounded hard-heads, which are boulders of gneisses and metamorphic rocks from the more northerly parts of eastern Ontario, but there is an abnormally large percentage of flat flagstones, which represent portions of the Ordovician sedimentary beds, torn off and carried along in the moraines of the ice. So abundant are these flagstones in many sections of the country that many fields of remarkably small acreage are completely fenced about by dry stone walls, 2 to 4 feet in thickness, built with flat stones picked from the field itself.

The second member of the Pleistocene series is a thinly bedded laminated clay of striking appearance (Fig. 15). It is a series of thin bands of rich clay, with alternate bands of marly clay, laid in perfect conformity. These banded clays, which the writer in his report[11] on "Clay and the Clay Industry of Ontario," grouped with the Saugeen clay, are found from the present level of lake Ontario up to an altitude of about 250 feet above the lake.

In the report just cited the writer claimed that these interlaminated clays represented depositions about the retreating ice, and were laid in the large lake-like bodies of water, that would lie ponded between the ice front and the higher land to the south of the glaciated area. At the time these banded clays were

[11] Ont. Bur. Mines, Vol. 15, Part II, 1906.

deposited the waters of an earlier enlarged lake Ontario, known to geologists as lake Iroquois, must have stood about 400 feet higher than at present, for geologists of the United States have shown that the beaches of lake Iroquois about Watertown are now 733 feet above the sea, or 487 feet above the present level of lake Ontario. Most of the area about Kingston lies below this level, therefore, remnants of these beds, lying in almost horizontal position, are to be found everywhere. These clays are remarkably free from boulders and pebbles, though they are occasionally found and are believed to be due to droppings from floating ice in lake Iroquois.

Loam is scientifically defined as an intimate mixture of clay and sand, and as many of these lighter bands in this laminated clay are sandy, the ploughing of such

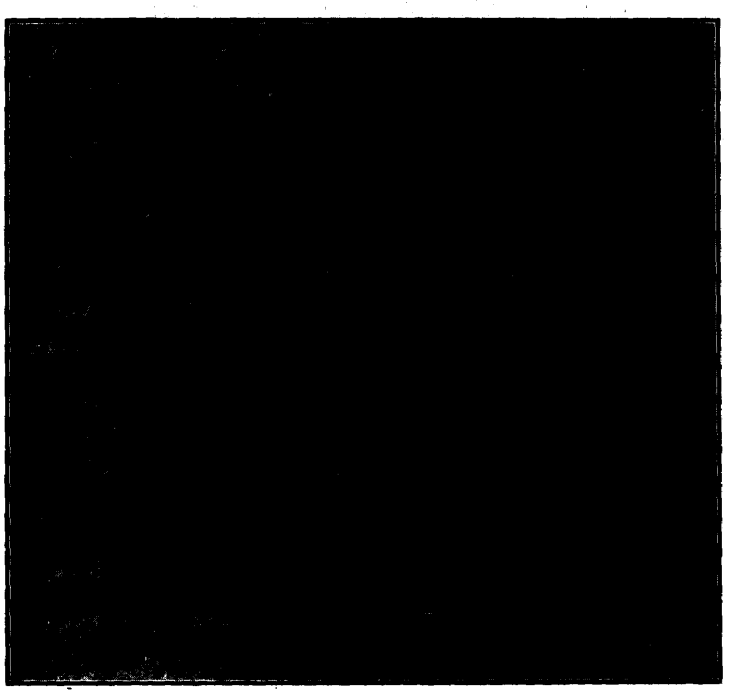


Fig. 15—Saugeen clay, composed of interlaminations of calcareous and ferruginous clay.

areas yields the very finest of loam land, and the farmers of this district readily differentiate between their clay land and their loam land. In many places the uppermost portion of the banded clay passes into bedded sand and occasionally into fine gravel. These have a well-bedded structure and, where they occur at all, are at the top of the series. Such deposits of sand or fine gravel, therefore, close the lake Iroquois phase of deposition. From much of the Kingston area they have been removed by later erosion, but occasionally remnants of them are left, yielding local supplies of sand and gravel.

The third and uppermost accumulation of Pleistocene times is only locally present, that is, it does not now, nor probably did it ever completely cover the area. It is a very thin layer of boulder clay or till, which in some places covers the laminated clays and sands. It is rarely over 2 to 4 feet deep and may mark a re-advance of the ice sheet. The laminated clays show no crumpling or crushing

of strata, as they would certainly do had a glacier ridden over them for ever so short a distance. The writer, therefore, suggests that this thin layer of drift represents the droppings from the melting of an ice pack, which jammed about the edge of the retreating ice sheet in certain localities. It is pointed out above that the last deposits laid in Iroquois lake were sands and fine gravel. This would indicate shallow water, or closeness of the ice front, and this is just the proper place for an ice pack to accumulate. Its melting would liberate sufficient moraine material to produce the thin layers occasionally found on the surface. Moreover, the mere melting of this ice would allow the moraine to drop vertically, and there would be little or no sorting of it. This would tend to produce the thin layer of till which is found above the Saugeen clay in certain places as described.

Recent

Other post-glacial deposits of small dimensions are found in local basins in the form of marl beds or peat-bogs. Both of these are very shallow and of no commercial value in this area, although in the adjoining county of Lennox and Addington, similar marl beds were dredged for years by the Rathbun Company, and used with blue clay, the accumulation of the first of these Pleistocene epochs, in the manufacture of Portland cement.

Interesting Exposures

This report will no doubt be much used by students of geology, and possibly by geologists visiting Kingston. The writer will, therefore, enumerate some of the most easily reached, and at the same time most interesting and instructive exposures in the area under consideration.

Grenville.

Exposures of Grenville crystalline limestones are abundant in the area mapped, but splendid exposures of typical Grenville almost free from any other material may be seen at Verona on the Canadian Pacific railway; at Perth Road on the Canadian Northern railway; at the north end of Collins lake, lot 21, concession II of Storrington township; at Brewer Mills, and Seeley on the Rideau canal.

Good examples of mixed Grenville limestone with rusty-weathering Grenville gneisses may be seen at Brewer Mills, lot 25, concession VIII, of Pittsburgh township; also on the road side, lot 23, concession VIII, of Pittsburgh, and at the south end of lot 8, concession VI of Pittsburgh; and also behind the school house, on the north end of the same lot. Extensive exposures of quartzite of Grenville age can be seen at Jackson Mills, lot 14, concession V, Kingston; also at the north end of lot 23, concession VIII, Storrington.

Grenville and Laurentian.

Broad belts of Grenville gneisses and schists free from crystalline limestone are to be seen in many places, but in no place was any such belt seen free from the *lit-par-lit* or the *mosaic* intrusions of Laurentian. Good exposures of these Grenville gneisses with their very marked bedded structure, along which the Laurentian intrusions have taken place, are to be seen at Deadman bay, and Cartwright point, Barriefield; at Kingston Mills on the east side of the gorge; just beyond Kingston Mills on the road side, lots 2 and 3, concession III, township of Pittsburgh; also just north of Battersea, lots 10, 11 and 12, in concession X of the township of Storrington. Splendid exposures are also to be seen at Oates, lots 17 and 18, concession VI, of Loughborough; also about Perth Road village; and three-quarters of a mile west of Verona station, on lots 13 and 14, concession XI, township of Portland.

Laurentian.

Large massive bodies of Laurentian are rare in this district, but a good exposure of what the writer believes to be Laurentian gneiss may be seen three-quarters of a mile north of Hartington station on the Canadian Pacific railway, on lots 7 and 8, concession IX, of Portland. Another interesting exposure of fine-grained pink gneiss occurs a quarter of a mile south of Brewer Mills on lots 27, 28, concession VIII of Pittsburgh. These are the only two places in this area where any large body of Laurentian gneiss, free from other formations, is exposed.

Algoman.

Excellent exposures of Algoman granites may be seen at the granite quarry on Barriefield heights; in the railway cutting at Kingston Mills, west end of the

bridge; about Findlay station on the Grand Trunk railway; at Battersea; between Oates and Perth Road; at Oates; and near the block house at Kingston Mills large fragments of the earlier Grenville gneisses, with their *lit-par-lit* intrusions of Laurentian gneiss may be observed, caught up in the bosses of Algoman granite.

Keweenawan.

Good exposures of Keweenawan trap and diabase, cutting the Algoman may be seen in the railway rock-cut east of the bridge at Kingston Mills; also 100 yards south of Rideau station house; also a quarter of a mile south of Findlay station. Many other exposures of these later fresh traps occur, for example, at Washburn on the Rideau canal, lots 37 and 38, concession X, township of Pittsburgh; east side of Collins lake, lot 23, concession I, township of Storrington; also on the opposite shore of the lake, lot 22, concession II, Storrington; again on lots 7 and 8, concession IX, township of Portland, three-quarters of a mile north of Hartington station.

Paleozoic.

The finest exposures of basal conglomerate that the writer has ever seen are shown in this area. Unconformable contacts of Potsdam sandstone and the pre-Cambrian, with large boulders of the earlier rocks embedded in the base of the Potsdam, are exposed at Joseph Gordon's house, lot 5, concession VI, township of Storrington (Fig. 12); also south of this along the drowned land shore, lots 2, 3 and 4, concession IV, of Storrington; on the opposite side of the Rideau canal at the base of the cliff at Blake's quarry, lot 9, concession V, Pittsburgh, where the famous so-called "fossil trees" occur. A most excellent section may be observed at Pitts Ferry, on the shore of the St. Lawrence river, where the Potsdam rests on Grenville gneisses; also a similar section along the shore at Whitmount.

It is pointed out above in considering the topography of the pre-Cambrian, that in many places island-like projections of these older rocks were above the Potsdam sea, so that no beds of this age were laid on such areas. By further submergence Ordovician beds were therefore brought to lie directly on the pre-Cambrian. Splendid basal conglomerates of this character, where the pre-Cambrian fragments and boulders are embedded in the base of the limestone, outcrop at Jackson Mills, at the cattle-pass under the railway, lot 14, concession V, township of Kingston; at the west end of the railway cutting at Kingston Mills; close to the Army stores at the foot of Barriefield hill; along the shores of Deadman bay, east of fort Henry, Barriefield (Fig. 11).

Pleistocene.

Though many are familiar with the typical boulder clay of Canada, it is probable that most people are unacquainted with the well-sorted interlaminated Saugeen clay of late glacial time. Good exposures of this clay may be seen on the lake shore at the foot of the hill, just west of Lake Ontario park, Kingston. Here the steep shore at the water's edge shows a good section of these clays. They may also be seen at the Kingston Brick and Tile Company's yard on Division street, Kingston. Unless fresh sections are exposed the real character of this clay cannot be well seen, for if exposed to weathering, it soon slakes down, so that the banded character is obliterated till this weathered material is removed, and a fresh surface is exposed. Digging therefore in any of the lower land areas about Kingston will expose sections of this laminated clay.

Economic Geology

It has been frequently stated that there is probably no other area of equal size, which has produced such a variety of economic minerals, as has that contiguous to Kingston. Within fifty miles of this city there has been produced from time to time the following products:—Mica, phosphate, graphite, gold, arsenic, copper, iron, lead, zinc, barite, talc, corundum, feldspar, quartz, actinolite, molybdenite, fluorite, pyrite, as well as building-bricks, lime, cement, building-stone and road metal. Productive deposits of all these minerals do not lie within the area covered by this report, but many do, and a few notes concerning them are added.

It is a fundamental principle of economic geology, that all metalliferous as well as other constituents of rocks, have been derived ultimately from the interior of the earth, have been brought to or near the surface through igneous activity, and have there suffered, as a rule, further concentration by natural processes, to become of economic value. With three periods at least, of igneous activity proven in pre-Cambrian times, namely, the Laurentian, the Algoman, and the Keweenawan, it is not surprising that these rocks should carry economic deposits of considerable variety and substantial value.

Feldspar.

Among the intrusive rocks mentioned in the earlier part of this report, are the pegmatites of late Algoman age. These are found cutting the large main masses of Algoman granite, as well as the earlier Laurentian and Grenville series. They are very coarse grained as a rule, so much so, that their chief constituents, feldspar and quartz, are mined separately in large quantities. This is only possible where these dikes cut gneisses, in which case they yield a beautiful feldspar carrying 13 per cent. of potash. These dikes have generally a pink colour and are very coarse grained. Most of this feldspar is mined about Verona and Bedford, on the Canadian Pacific railway, and is shipped from there to the United States, to be used for glazing white earthenware dishes, lavatory equipment, terra-cotta tiling, electric insulators, reflectors, etc. The quartz is shipped to the Niagara peninsula for use in the various silicon combinations, so largely manufactured there. A more recent use of the second grade of feldspar is for the extraction of its potash for the manufacture of artificial fertilizers. This industry may be considerably developed in the near future.

Where Algoman dikes cut Grenville crystalline limestones, they are no longer pink, but white or bleached, and do not show the constituents segregated into masses fit for mining, but on the contrary, exhibit the most intimate mixture of their quartz and feldspar. Much of it is actually graphic granite, where the most pronounced intergrowth is evident. The feldspar in this case is no longer the potash-rich orthoclase and microcline, but is a pale to white oligoclase, which carries about 6 per cent. of potash and 3.5 per cent. of soda. From these facts it is clear that the Algoman pegmatites are of economic value where they cut gneisses, but are of no worth where they cut the crystalline limestones. This fact should prove instructive to prospectors in the search for additional supplies of feldspar in this and adjoining areas.

Below are given two analyses of the feldspar at the Richardson mine, Bedford township, Frontenac county:[11a]

	Per cent.	Per cent.
SiO_2	66.23	65.40
Al_2O_3	18.77	18.20
Fe_2O_3	trace	trace
K_2O	12.09	13.90
Na_2O	3.11	1.95
CaO	0.31	Nil
MgO	Nil	Nil
Loss on ignition	Nil	0.60

Mica and Phosphate.

Southeastern Ontario has long been known as an important producer of amber mica. In the "Geology of Canada," issued by the Geological Survey of Canada in 1863, reference is made by Sir William Logan to the occurrence of mica in this region. On page 796 is a brief statement of important mica occurrences in Ontario, and the paragraph closes with this statement:—

It appears probable that by further exploration in this region, and in Grenville, sufficient quantities of mica could be obtained to supply a large demand.

All early reports of mica occurrences speak of its association with phosphate, and in fact, the phosphate industry flourished long before the mining of mica was carried on. In 1868 apatite was mined by the Rideau Mining Company in North Burgess township, and was shipped to Germany. It then brought seven dollars per ton. In 1871 apatite was discovered in the township of Loughborough by H. G. Vennor.[12] Mica then began to be mined as a by-product in the phosphate industry. It was not, however, until after 1890 that there was any appreciable demand for mica. Of the great amount that had been mined in the phosphate industry, and thrown on the dumps, only a very small portion of the choicest sizes procured a market.

After 1890 both mica and phosphate found sale for a while, but the placing of the easily mined phosphates of the southern States on the market, soon stopped the sale of the harder and more costly phosphate of southeastern Ontario. The mica industry continued to grow, however, and has been a valuable one ever since. It is not the writer's intention to deal in detail with this industry, a monograph, No. 118, having been issued by the Department of Mines, Ottawa, in 1912, which is full of information for those who wish it in detail. There are certain points, however, regarding the origin of mica and phosphate deposits, that do seem worthy of note here. The detailed mapping of this area gave the writer an opportunity to study, and aid in deciding, some much debated points as to the origin of phosphate and mica deposits in pre-Cambrian rocks.

It is probably natural that the first theories of origin suggested for phosphate should be organic, and early Canadian geological literature assigns this theory.

[11a] Ont. Bur. Mines, Vol. X, 1901, p. 26.
[12] Geol. Sur. Can., 1871.

Vennor[13], G. M. Dawson[14], Fielding[15], Davidson[16], J. W. Dawson[17], and Harrington[18], claimed that the phosphate deposits were derived from organic remains, originally present in the sedimentary gneisses and limestones in which they are now found. History repeats itself, and, as in all similar discussions, an exactly opposite view was soon put forth by other geologists. Quite in contrast with the organic theory was the theory that these deposits were of purely igneous origin. This theory has been supported by Selwyn[19], Bell[20], Ells[21], Coste[22] and others.

Coste sums up the matter thus:—

We believe we have gathered year after year strong and clear evidence to show that not only our deposits of iron ore in Archean rocks, are of eruptive or igneous origin, but also that our deposits of phosphate are exactly similar, and have also the same origin.

Two theories more opposed in character, could not have been put forth to explain the same phenomenon, but there was considerable evidence for each, and from the study of individual deposits, it would be almost possible to prove either theory. The writer, after mapping this area geologically, saw certain relationships which show that both of these theories are partially correct, but that a combination of the two is necessary to account for the deposits satisfactorily. Certain essential ingredients were present in the sedimentary rocks as claimed by the first school; while certain other ingredients were introduced by the igneous activity, and the aqueo-igneous combination produced the results now found.

Deposits carrying phosphate and mica are often of quite irregular shape, the so-called "pockets." As a rule they are rather vein-like in that they follow the strike of the gneisses, or the contacts of the gneisses with crystalline limestones. A few deposits do cut across the general rock structure at an angle. Generally there are no walls, or sharp contact planes, between phosphate deposits and their surrounding rocks. The beds are extremely irregular in shape, and only rarely does anything like a true vein show. The deposits are usually made up of pyroxene, phlogopite, apatite, and calcite, named in the order of their crystallization. Many of the mica deposits are free from calcite, and some are free from apatite or phosphate, but none are free from pyroxene.

This has led to the common statement that our mica and phosphate deposits are found in "pyroxenites," and these pyroxenites have been described as intrusive, plutonic masses of coarse crystallization, which have intruded the gneisses and crystalline limestone. This is what a pyroxenite should be, but not what these actually are.

The writer got his first hint as to the explanation of the origin of these deposits while examining a contact of Algoman granite with Grenville crystalline limestone on lot 5, concession VI, of township Storrington. No other rocks were to be seen here so that the contact was a clean one between these two rocks. Along the contact

[13] Geol. Survey of Canada, Rep. Prog. 1874-5.
[14] Trans. Ottawa Field Club, 1884.
[15] Eng. Mining Journal, 1886.
[16] Trans. A.I.M.E., 1892.
[17] Quart. Journal Geol. Soc., Vol. XXXII, 1876.
[18] Geol. Survey of Canada, Rep. Prog., 1877-8.
[19] Geol. Survey of Canada, Rep. 1888-9.
[20] Eng. & Mining Journal, 1886.
[21] Can. Mining Review, Vol. XII, 1893.
[22] Geol. Survey of Can., Rep. 1887-8.

were developed scattered crystals of pyroxene, phlogopite, apatite, calcite, scapolite, graphite, and other minerals, showing clearly that these minerals had developed as contact metamorphic crystallizations, and were the result of a siliceous magma, coming in contact with a dolomitic limestone country rock. The lime and magnesia acquired from the dolomite formed with the silica of the intrusive the minerals found in these so-called " pyroxenites," the necessary amounts of alumina, iron oxides, and alkalis, being just as easily accounted for as the more abundant constituents.

It is pointed out in the early part of this report that the Laurentian granites intruded the Grenville limestone and lime-holding sediments in great amount; and that these intrusions usually produced an elongated lens-like, or plate-like shape, depending upon the perfection with which they followed the structure of the pre-existing gneisses and schists of Grenville age. It is obvious therefore that the contacts would be vein-like in shape, as a result of following the gneissic structure of the country rocks. Thus the shape of the so-called " pyroxenite dikes " or mica veins is accounted for. They are simply contact metamorphic deposits produced by the intrusion of the siliceous Laurentian granite into the basic Grenville limestone, rich in lime and magnesia.

Testing this theory the writer then traced the contacts of the main Laurentian belts with the crystalline limestone, and was astonished to find how perfectly the economic deposits of mica are strung along such contacts. In many cases the contact produced a rather compact, fine-grained, crystalline rock, composed largely of pyroxene, mica and apatite, and could very easily be taken for a pyroxenite; and its position would appear to be intrusive into the Grenville limestones and gneisses, as has been so frequently claimed. At other places, more open and spacious contacts would develop the large crystals for which this class of deposit is famous. Mica crystals measuring six feet across the base have been found in the Canadian General Electric Company's mine at Sydenham. Pyroxene crystals six inches square and eighteen inches long; apatite crystals ten inches in diameter; sphene four inches in cross section; zircon half an inch to a side and an inch and a half long, and other crystals of similar dimensions, have made these deposits famous as collecting ground for mineralogists.

The bulk of the deposits are of course along the contact in vein-like bodies, but certain fractures cross the gneiss and bedding planes of the crystalline limestone, giving rise to the so-called " cross-fissures," or dikes which cut the structure of the country rock. It is clear that the size of the crystals, and therefore the economic value of the mica deposits, depends on the openness of the ground in which the crystals grew. Great areas, therefore, of so-called " *mica rock*," pyroxene and phosphate, are found which yield no marketable mica, and are readily taken for basic intrusive igneous rocks. They are too dense and compact to have given opportunity for the development of large crystals and are therefore of no economic value. The writer would, therefore, advise prospectors for mica to search out contacts of crystalline limestone with Laurentian gneisses, and follow along these contacts searching for places where sufficient openings or spaces were formed to allow for the growth of large crystals. That the granitic intrusion which caused the metamorphism and mineralization, was Laurentian in age, and not Algoman, is certain, because both Algoman and Keweenawan dikes cut these mica-phosphate deposits.

It has been stated in the literature, and more frequently by mica miners, that mica is "pockety," and only "superficial" in its development, and that it will "not go deep." These statements are only partly true. There is no reason to limit the depth to which mica may be found, but it is such an easily cleavable and very fissile mineral that, at depth, mica crystals are apt to slip and be wrinkled or crumpled by pressure, which renders them useless for economic purposes. Just as one often says that certain segregated ores have a commercial wall, so one can say that mica has a commercial depth. If there has been no serious pressure to deform the mica physically, there is no reason why it should not follow indefinitely down the contacts on which it has formed.

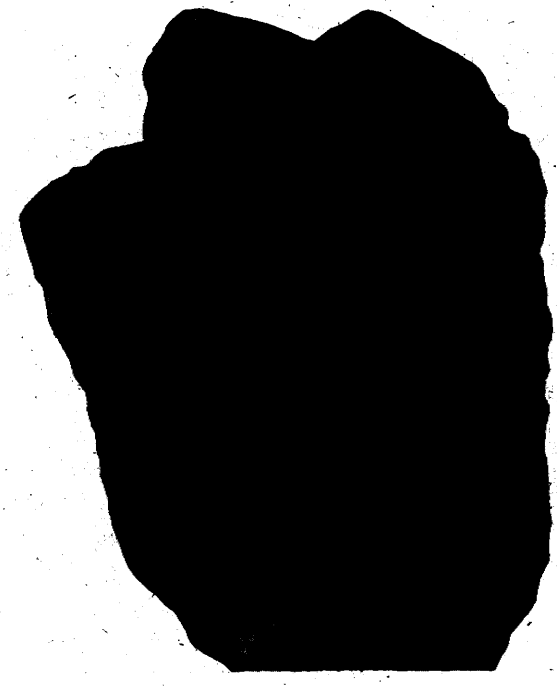


Fig. 16—Polished lead and zinc ore specimen from Frontenac Lead mine, showing encrustation vein filling.

Lead and Zinc.

In the year 1870 an outcrop of galena was found on the south half of lot 16, concession IX, of Loughborough township. It was worked in a desultory fashion, by the local inhabitants for five years. Sufficient galena was shown to attract an English company, and in 1875 the Frontenac Lead Mining and Smelting Company was formed.[23] This company sank a shaft 250 feet deep, and ran five fifty-foot levels. In five years it took out over 2,000 tons of ore, which was reported to average 12 per cent. in lead, and five ounces of silver[24] to the ton of galena.

[23] The Frontenac lead mine is also described by W. L. Uglow in Vol. 25, Part II, 1916, Ontario Bureau of Mines, pp. 18-21 and 36-42.

[24] Idem, p. 20. W. L. Uglow, however, believes that recent silver determinations have established beyond doubt the fact that the ore very seldom contains more than one and a quarter ounces of silver per ton of galena.

This company traced the vein to the northwest for about three-quarters of a mile, and opened up two other shafts, showing a mixed ore of galena and zinc blende. The ore at the original opening, or No. 1 shaft, was entirely galena. The vein was traced, also, to the southeast into concession VIII, a distance of nearly a mile, where the large mass of Algoman granite, shown on the map, is met with, and where the vein showed no further development. At shaft No. 1 the wall rocks are gneiss, partly Laurentian in age and partly Grenville in *lit-par-lit* intergrowth. This country rock extends southeast to the Algoman intrusive. Following the vein northwesterly from No. 1 shaft, it passes into a small swamp, and when it emerges at the other edge, the wall rocks are Grenville crystalline limestone. The contact

Fig. 17—Polished lead and zinc ore specimen from Frontenac Lead mine, showing geode filling by encrustation method.

between the gneiss and crystalline limestone lies in the swamp and cannot be seen, but at the southwest edge of the swamp a belt of pyroxene phosphate rock is developed carrying mica as has just been described.

The gangue of the lead vein is coarsely crystalline calcite, which makes a very striking vein in the gneiss and crystalline limestone. It is from six to twenty feet in width, dips vertically, and shows a remarkable ribboned or banded structure with the sulphides of lead and zinc. It is evidently a typical encrustation vein as shown by the polished ore samples illustrated herewith. The first illustration (Fig. 16) shows a polished specimen of the banded vein, while the second (Fig. 17) shows the encrusted vug-like nature of other parts of the vein.

Regarding the origin of this deposit it is evident that the opening is not the result of solution, for the vein is a distinct fissure at least one and a half miles long, and with distinct strike and dip, sharp clean-cut walls, no impregnation of the country rock by ore or gangue, and cuts at least one contact between gneiss and crystalline limestone, across their general strike. It is clearly a fracture of post-Laurentian age. The writer has already stated that towards the southeast the vein soon meets the great Algoman batholith shown on the map south of Perth Road. In other parts of southeastern Ontario north and west of this area, the Algoman has been shown to be the immediate cause of certain gold-bearing quartz bodies, and these auriferous quartz bodies often show galena as an accompanying constituent, for example, the Belmont, Deloro, Ore Chimney, Big Dipper, and other gold deposits. The Algoman granite intrusion, therefore, possibly caused the fracturing,[25] and produced the space necessary for the ore body; while the mineralizers that accompanied the end action, or pegmatitic phase of the Algoman, could contribute the ore filling; the highly calcareous Grenville country rock would contribute the gangue of calcite.

Fig. 18—Barite vein in Ordovician limestone.
Lot 17, con. IV, Kingston township.

Barite.

On lot 17, concession IV, of the township of Kingston, is a barite vein that cuts the flat-lying Ordovician limestone (Fig. 18). At this point it is from one to four feet wide. It dips vertically and strikes northwest; it is claimed it can be

[25] In several cases in Ontario veins of lead sulphides cut Paleozoic rocks, and are therefore younger than these rocks. This is true of the lead deposits at Galetta, and Ramsay lake. The Frontenac lead mine could be of the same age as the Galetta and Ramsay lake deposits.

picked up along this strike for a distance of fourteen miles. The limestone is dense and hard with shaly partings, and its contact with the barite is very sharp and clean; there is no transition whatever from the vein into the country rock. Moreover, along the contact is a coating of anthraxolite, and some fluorite, all of which the writer takes to indicate that this vein has not filled from the surrounding country rocks, but owes its origin to an aqueo-igneous source.

Approximately one hundred tons of barite have been mined from the east end of this vein. The mineral was ground in an old burr-stone flour mill near by and shipped as a mineral pigment for paint manufacture. Nothing has been done with this vein for over twenty years.

Paving and Building Stone.

The Algoman formation around Findlay station, on the Grand Trunk railway, possesses such splendid jointing that it has been quarried for building stone and the smaller blocks have been chipped to cobble stone size and sent in car-lots to Montreal, Toronto, Ottawa and other places to be used for paving purposes. Both the granitic and syenitic phases of the Algoman have been used from this vicinity and both yield an excellent cobble stone. Larger blocks, the quality of which is excellent, have been, and are still, quarried for building purposes.

Trap.

The Keweenawan trap dikes, of which many are shown on the map, would yield the very best road metal procurable for macadam roads. The dikes shown on the point of lot 18, concession IX, township of Storrington, have been quarried. As the product was mistaken for magnetic iron ore it is still on the dumps. This dike is most handily situated for mining and shipping by boat on the Rideau canal. Similar dikes are shown at Washburn, also on the Rideau canal, and quite handy for water shipment. Unfortunately these dikes are of rather small dimensions, so that the supply of road metal is limited. Other larger areas of trap and basaltic rocks occur about Jones falls on the Rideau canal. These might prove of sufficient size to supply much needed road metal. This area lies beyond the scope of this report, however, so no detailed description of it can be given.

Lime.

The Grenville crystalline limestones have been much used as a source of lime. In the vicinity of Verona and Bedford, splendid kilns were erected and lime burned for shipment over the Canadian Pacific railway. The Ordovician limestones about Kingston would yield the highest quality of lime, but at present no kilns are being used on either class of rock except for purely local supplies. It would be difficult, however, to find more suitable limestone or more favourable locations for shipping than are to be had in this vicinity.

Building Stone.

As already mentioned, the Algoman granites and syenites around Findlay have been quarried into large blocks and shipped for building purposes. Algoman granite was also quarried at Barriefield and good red granite blocks were obtained. A solid, fresh, even-grained Algoman mass would yield good building stone in most places. Only rarely does it show any gneissic tendency, it is for the most part massive, and its remarkably good jointing makes quarrying a rather easy matter.

The Potsdam sandstones, particularly the red ferruginous sandstone, has been quarried and used for decorative stone in brick buildings, and at other times for the whole structure (Fig. 19).

The writer suggests that the buff to white lower beds of Potsdam sandstone are so free from iron and other impurities that the refuse material from a quarry

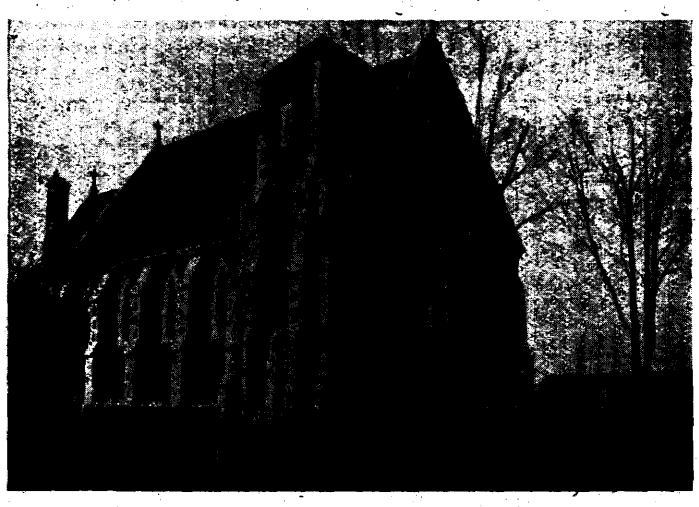


Fig. 19—Roman Catholic church at Cushendall built of Potsdam sandstone, relieved with Black River limestone.

might prove very valuable as a source of glass-sand. The Potsdam exposures on the St. Lawrence waterway, on lots 28, 29 and 30, concession II, township of Pittsburgh, would be worth investigation in this respect.

Kingston has long been known as the Limestone City owing to the fact that a large number of its homes, as well as its public buildings, are built of this rock. It is doubtful if any better building stone is to be found in Canada than the Black River beds of Kingston and vicinity. They yield a beautiful dove-blue coloured stone, of very even grain and of almost any desired thickness of bed. They are remarkably free from fossils and, therefore, yield uniform, even-grained blocks. They are easily quarried almost anywhere in the vicinity and are soft and easily shaped when freshly quarried. They soon lose their quarry-sap, however, and whiten, and harden very much after exposure, giving the building a greyish-white appearance that is clean and attractive. Kingston's public buildings, churches, city hall, court house, hospital, penitentiary, Rockwood asylum, and the splendid group of Queen's University buildings, are all built of this Black River

limestone.[26] It is doubtful if any finer group of buildings for uniformity of material is to be found in the Dominion. The freedom from fossils is the chief feature of this success. For uniformity of texture and evenness of grain the writer has seen nothing to surpass the limestone of this area as a building stone.

Building Brick.

The Pleistocene deposits of the Kingston area are not well suited to the manufacture of brick. As explained in the early part of this report the surface deposits are Saugeen clay, which are thin-bedded, interlaminations of calcareous and ferruginous clay. The layers rich in lime burn to buff or so called white brick; while the ferruginous layers burn to a rich red. The result is that the clays when dug are mixed up, and as perfect mixing is most difficult, the product is spotted. The body of the brick is red, but buff spots of calcareous clay are scattered through it, in many cases spoiling the brick for any purpose except inside walls. If the clays can be thoroughly mixed together, the red ferruginous clay will mask the buff or white burning clay, and a good red brick will result.

[26] See Frontispiece for illustration.

Appendix I

THE ORDOVICIAN LIMESTONES OF THE KINGSTON AREA[a]

By E. M. KINDLE

General Stratigraphic Relations

The Paleozoic limestones of the Kingston area comprise a series of beds showing a wide range of physical characteristics. They have been divided on the basis of physical and faunal differences into the formations which are discussed in the following pages.

The Paleozoic section of the Kingston district includes in the eastern part of the area the Potsdam sandstone at the base of the limestones. Elsewhere throughout most of the region southwest of the Frontenac axis the Potsdam is absent and the limestones and clastic beds at the base of the Paleozoic rest directly on the pre-Cambrian. The Paleozoic rocks are separated from the pre-Cambrian series by a great unconformity. The older series includes a wide range of types of crystalline intrusive rocks intimately associated with ancient sediments which have been subjected to intense metamorphism.

The old pre-Cambrian lands which the Cambrian and Ordovician seas invaded presented topographic features essentially similar to those now found in the Laurentian areas of southern Ontario which have been recently denuded of their Paleozoic cover. Remnants of the Paleozoics on the borders of the pre-Cambrian area afford evidence of the irregular and hilly character of the surface on which the earliest Paleozoic rocks of the region were laid down. No locality affords clearer evidence of the character of the pre-Cambrian relief than the Kingston area. Fort Henry hill, a promontory just east of Kingston rising about 100 feet above the St. Lawrence river, illustrates the character of the pre-Cambrian topography which the transgressing Paleozoic seas encountered. This is a pre-Cambrian hill with a thin veneer of Ordovician limestone which has been almost entirely removed by erosion from the eastern side. A remnant of the limestone is still to be seen, however, at water level at the head of the bay on the east side of the hill and another patch is preserved at a higher level on the same side where the slope of the hill is very steep. The exposed crest of the ridge is gneiss, but patches of limestone overlie this formation a very few feet below the highest point. On the west slope most of the limestone cover remains, the beds nearest the gneiss often adjusting themselves to its slope.

Formational Nomenclature

Historical.—A brief review of the contributions of earlier writers to the subdivision and nomenclature of the Paleozoic rocks of this district will aid the reader to understand the reasons for adopting the names used in this paper for the forma-

[a] Published in co-operation with the Geological Survey Branch of the Dept. of Mines, Canada.

tions which are described. Only those papers that have a bearing on the nomenclature of the limestone formations are mentioned in the following notes.

Capt. R. H. Bonnycastle, R.E.,[1] appears to have been one of the first writers to attempt a description of the geology of the Kingston area. He gives in a paper published in 1830 considerable information concerning the distribution of the limestones and granitic rocks at the head of the St. Lawrence and mentions the occurrence of fossils in the former. A second paper[1a] describes in some detail the bands of crystal-like zones in the limestone known now as stylolites; the latter are even now but imperfectly understood. The nomenclature used in Captain Bonnycastle's paper is that of the Wernerian school which was then being rapidly displaced by that of the English school of geologists.

Fossils were collected at Kingston in 1842 by Sir Wm. Logan.[2] In Sir Wm. Logan's work on the Geology of Canada[3] which appeared in 1863 the formation names used by the New York State geologists were applied to the corresponding formations at Kingston. Logan referred the limestones of the Kingston district to the Birdseye, Black River and Trenton formations.

The name "Lowville limestone" was proposed by Schuchert and Clarke[4] in 1899 to supersede the "Birdseye" of the New York section. Since that date the term Lowville limestone has generally been used in Ontario in place of Birdseye.

Dr. Ells[5] in a paper published in 1903 pointed out the absence from the Kingston section of the Chazy and Califerous which are well developed to the north and east. The lowest limestone beds were referred to the Black River formation and a few of the fossils occurring in them were listed by Dr. Ells. A marly arkose was noted at the base of the limestone in some of the sections.

In 1905 Dr. J. F. Whiteaves[6] described from Kingston Mills a new orthoceratite previously referred to *Nanno aulena,* under the name of *Nanno kingstonensis.* This, he states, is associated with an *Actinoceras* or *Paractinoceras* n.sp. and a small *Raphistoma.* "These fossils would seem to indicate that the limestone at Kingston Mills is probably not older than the Chazy formation, and not much if at all newer than the Black River limestone."

Dr. H. M. Ami[7] presented a paper before the Geological Society of America in 1902 in which he pointed out certain differences between the formational sequence on the eastern and western sides of the Frontenac axis. This paper introduces the name Rideau sandstone for beds between the Black River and pre-Cambrian west of the Frontenac axis. The introduction of the new term "Rideau sandstone" for beds of variegated colour and composition at the base of the Paleozoic limestone series is the principal point of interest in Dr. Ami's paper in this connection.

Prof. H. P. Cushing visited this area during the progress of his mapping of the formations on the New York side of the St. Lawrence and has included in his

[1] On the Transition Rocks of the Cataragui, Amer. Jour. Sci., Vol. 18, 1830, pp. 85-104.
[1a] Ibid, pp. 74-82, 1831.
[2] Amer. Geol., Vol. XXXV, 1905, p. 29.
[3] Pp. 176-183.
[4] Science, Dec. 8, 1899, Amer. Geol., Feb., 1900, Mem. N.Y. State Mus., Vol. III, No. 3, p. 8, 1900.
[5] Notes on some interesting contacts in the Kingston district. Trans. Roy. Soc. Can., 2nd ser., Vol. IX, sec. 4, pp. 97-108, 1903.
[6] Amer. Geol., Vol. XXXV, 1905, p. 27-29, pl. 2-3.
[7] Ordovician succession in eastern Ontario; Bull. Geol. Soc. Amer., Vol. XIII, 192, pp. 517-18.

report a reference to the Kingston section. In a preliminary paper [8] on this work Cushing described two new formations, the Pamelia limestone and Theresa dolomite from near the base of the Ordovician section.

In the Kingston district Cushing [9] found no evidence of the presence of the Theresa and stated that the Pamelia rests either on the Potsdam or pre-Cambrian and shows at times astonishingly coarse basal conglomerate which he [10] considered the equivalent of Ami's Rideau sandstone.

In reporting on field work for 1911 Dr. P. E. Raymond [11] states he had recognized the Pamelia formation at Kingston Mills and Rush bay on Wolfe island near Kingston. An undescribed species of *Tetradium* was found at the first named locality and *Isochilina? clavigera* at Rush bay. Dr. Raymond [12] published in 1914 a table giving a "tabular view of the Middle Ordovician formations of Ontario, New York and Quebec." In this table the Black River group of central Ontario includes the Leray, Lowville and Upper Pamelia.

Nomenclature Used

The preceding review will suffice to show that a number of workers in the geological field have contributed through a period extending over eighty-five years to our present knowledge of the Ordovician limestones of the Kingston area. In most cases these contributions have been incidental to the prosecution of geological studies in other areas and correspondingly fragmentary. The nomenclature used has varied rather widely. This is particularly noticeable with reference to the term Black River which was employed by Vanuxem [13] in 1842, and included all the limestone series in the Black River valley between the Trenton and the pre-Cambrian. This term has also been sometimes used in two district senses by the same author—as a group and a formation term. The Black River as defined by Ulrich [14] is limited above by the Trenton and below by the base of the Lowville, the Pamelia being placed in the Stones River group and separated from the Lowville by the Blount group of Pennsylvania. It is here used with essentially the same latitude as applied by Vanuxem. The nomenclature presented in the table below represents the broader facts of our present knowledge of the succession and characteristics of the Paleozoic rocks of the district.

[8] Bull. Geol. Soc. Amer., Vol. XIX, 1908, p. 159.
[9] N. Y. State Mus. Bull. 145. p. 67-70, 1910.
[10] Geol. Soc. Amer. Bull., Vol. XIX, p. 167, 1908.
[11] Can. Geol. Surv., Summ. Rept. for 1911 (1912), p. 353.
[12] The Trenton group in Ontario and Quebec, Can. Geol. Surv. Summary Rept. for 1912 (1914), pp. 342-350.
[13] Geol. of N.Y., Pt. III, pp. 38-45, 1842.
[14] Bull. G.S.A., Vol. XXIII, 1911, pl. 27.

Tabular View of Ordovician Stratigraphy in the Kingston Area

		Formations and Members.	Lithology.	Characteristic fossil.
ORDOVICIAN.	TRENTON GROUP.	Trenton limestone.	Limestone and interbedded shale.	*Dalmanella rogata.*
	BLACK RIVER GROUP.	Leray and Lowville limestones.	Coarse limestones.	*Columnaria halli.* *Tetradium cellulosum.*
		Pamelia formation.	Fine-textured limestone.	*Leperditia fabulites.*
		Rideau beds (basal member of Pamelia.)	Shale, sandy limestone and conglomerate.	*Nanno kingstonensis.*
CAMBRIAN.		Potsdam sandstone.	Sandstone.	Barren.

Description of Formations

Black River Group

Pamelia Formation.—The rocks of the Pamelia formation comprise fine textured limestones with a series of argillaceous and sandy beds at the base which rest on the pre-Cambrian schists and quartzites where the Potsdam sandstone is absent as in the central and northern parts of the area. These clastic beds at the base of the Pamelia limestone will be treated here as a member of the Pamelia formation and designated as the *Rideau beds.* These appear to be the beds called the Rideau sandstone by Ami,[15] although no type section was named by this author. The best exposure known of the Rideau beds occurs in the railway cut called the Kingston Mills section on the west side of the Rideau canal near Rideau station, which will be considered the type section of the Rideau beds. The character of the lithology is shown in the following section:

SECTION AT KINGSTON MILLS.

a. Greenish grey silicious limestone with numerous quartz pebbles ⅛" to 1" in diameter. *Nanno kingstonensis* abundant at top ..... 6 feet
b. Hard olive shale, weathering buff ..... 2 "
c. Greenish calcareous sandstone, with numerous quartz pebbles 1-16" to ⅛" in diameter ..... 1½ "
d. Greenish shale and limestone with an abundance of small quartz pebbles in limy bands ..... 8 "
Granite boulders 1′ to 3′ (greatest dimension) in lower two feet, but not closely placed.
e. Granite (pre-Cambrian) .....

At a higher level near the top of the hill a few hundred yards southeast of the Kingston Mills section the nearly pure limestone beds of the Pamelia are seen outcropping in the quarries.

At the Jackson's mill section, which is located five miles northwest of Kingston, the entire thickness of the Pamelia formation and its relations to the

[15] Bull. Geol. Soc. Am., Vol. XIII, 1902, pp. 517-518.

pre-Cambrian below and the Lowville above are well exposed. The base of this section is exposed near the cow path under the railway in the big curve north of Jackson's mill. The lower part of the section exposed here shows the following beds:

SECTION A QUARTER OF A MILE N.E. OF JACKSON'S MILL.

a. Greenish grey shale	4½	feet
b. Dove-grey fine-textured limestone with perfectly preserved mud cracks at top. No fossils observed	12	"
c. Grey limestone with occasional pebbles of quartz in lower part. A small *Orthoceras* and *Cyrtodonta* present	2	"
d. Sandy calcareous beds with large quartzite pebbles and small boulders up to one foot in diameter in basal three feet	5	"
e. Quartzite (pre-Cambrian)	3	"

The lower seven feet of this section above the pre-Cambrian represent the Rideau beds. Here as at Kingston they contain a fauna unknown in the pure limestone of the Pamelia which follows: *Nanno kingstonensis* which is the most abundant fossil in these beds at Kingston Mills appears to be represented by a poorly preserved specimen in the Rideau beds at Jackson's mill.

The limestone beds of the Pamelia in the Jackson's mill section have a thickness of about 40 feet which is probably an average thickness of these limestones. An interesting feature of the Pamelia limestone in this section is the bed of beautifully preserved mud cracks about 15 feet above the base of the section. The top of the Pamelia limestone in the Jackson's mill section is marked by a 10-inch bed of limestone containing small and somewhat angular limestone pebbles. This bed is followed by the coarse-textured grey limestone of the Lowville holding an abundance of *Tetradium*.

The Pamelia limestone is generally a fine-textured rock of dove-grey colour. It lies in even-bedded strata usually 6 inches to 2 feet in thickness, many of which have a texture approaching that of lithographic limestone. A section of these beds usually shows some interbedded strata of argillaceous shale and others of magnesian limestone. The quarry section on the west side of Fort Henry hill at Kingston which is described below affords a representative section of this limestone.

QUARRY SECTION WEST SIDE FORT HENRY HILL.

Hard grey limestone with texture of lithographic limestone	8	feet
Drab, rather soft, magnesian limestone	12	"
Hard blue grey limestone with small ostracods	14	"

A bed of greenish grey limy shale which lies near the base of the city quarry section in the Pamelia is exposed along the Canadian Pacific railway in the north-eastern part of Kingston. Two or more beds of drab or greenish shale each 4 feet to 6 feet thick are usually interpolated between the fine-textured, even-bedded grey limestones which comprise the major part of the Pamelia formation.

In some of the upper beds of the Pamelia, bands of stylolites are common. In some cases percolating surface waters have accelerated solution along the contact of the upward and downward pointing prisms of these bands, giving the effect of interlocking stalactites and stalagmites.

Geodes filled with calcite are common in some of the impure limestone beds of the Pamelia.

Joints are present but quite irregular in direction. The joints are usually vertical but a few are inclined at considerable angles to the vertical.

A very characteristic feature of the Pamelia limestone is the presence in the lower half of the formation of beds with very perfectly preserved sun-cracks. Excellent samples of these sun-cracks are exposed over a considerable part of the floor of an old quarry just northwest of the Canadian Pacific railway roundhouse in Kingston. They occur here in limestones of very fine even texture. Although sharply outlined on the surface of some of the beds they do not penetrate any perceptible distance into the limestone. Sun-cracks occur in quarries on the north side of Kingston at various horizons in the Pamelia. Associated with the sun-cracks in some of the quarries numerous elevations occur rising from 1 to 3 inches above the adjacent flat, sun-cracked surface. These curious little hummocks vary from a few inches to a couple of feet in diameter and have, in most cases, a highly irregular outline. They are cut, like the adjacent surface, by sun-cracks. The presence of sun-cracks in the Pamelia limestone indicates that the limestones were formed, at least in part, in very shallow water and within the limits of the intertidal zone. The lagoonal beach conditions under which these beds must have accumulated are probably responsible for the great scarcity of fossils other than ostracods which characterizes these limestones. The ostracods occur in some beds in abundance. Most of the species are new, according to Dr. E. O. Ulrich, who kindly examined the collection made. The Pamelia limestone fauna includes *Bathyurus spiniger, Leperditia fabulites* and *Isochilina armata.*

All of the limestones east of the Rideau canal, with the exception of one or two small patches, belong to the Pamelia formation. West of the canal this formation comprises the lower portions of the limestone section north and northwest of Kingston.

Lowville and Leray Limestones.—The Black River limestones above the Pamelia on the New York side of the St. Lawrence river have been separated into three distinct formations known respectively as the Lowville, Leray, and Watertown limestones. The Watertown, the highest of these, is not distinguishable at Kingston. The cherty beds said to characterize the Leray on the New York side of the river are absent or very slightly developed in the Kingston area. The very slight physical differences which can be recognized between the lower and upper portions of these limestones make it convenient to treat the Leray and Lowville in this area as a single lithologic unit.

The base of the Lowville is generally marked by a distinct change in the lithology, the fine-textured even-bedded strata of the Pamelia giving place to coarser-textured limestone in which the bedding is less regular and the colour a darker grey. The lower beds of the Lowville in some sections show cross-bedded layers and aggregations of fossil fragments representing current action. A thin bed of limestone containing small limestone pebbles is sometimes present at the top of the Pamelia. In the upper part of the Lowville-Leray limestones the beds show a somewhat rubbly character, breaking up under weathering into irregular-shaped pieces a few inches in diameter. Bands of nodular limestone in which the rounded

pebble-like masses are interspersed through a somewhat shaly bed are sometimes met with. An example of this nodular limestone occurs at the natural bridge on Wolfe island, a short distance east of Marysville. The sections northwest of Kingston show a thickness of about 35 or 40 feet of these limestones above the Pamelia. The abundance of fossils, darker colour and generally coarser texture of the Lowville and Leray limestones distinguish them from the Pamelia limestone. The extremely regular laminæ which characterize many beds of the latter are not found in the Lowville. Certain beds in the Lowville show cross bedding and others are composed of a mass of fossil shells. Large cephalopods and numerous gasteropods are conspicuous elements in the composition of the limestone at many points.

The basal beds of the Lowville are characterized faunally by the appearance in them of *Tetradium cellulosum* which is present in great abundance in the basal beds of many sections. A *Cyrtodonta* allied to *C. huronensis* also occurs in great numbers in these lower beds. In some sections a species of *Stromatocerium* forms boulder-like masses in the limestone. Good examples of these masses occur on Wolfe island near water level in the western part of the village of Marysville. They also occur in the roadside section one-third of a mile southwest of Shannon tollgate, five miles north of Kingston. The upper part of these limestones is characterized by *Columnaria halli* and a species of *Streptelasma* which are unknown in the lower beds. In the ostracods and bryozoa of the Shannon section Dr. E. O. Ulrich recognizes the presence of the Decorah zone. He writes[16] regarding this late Black River fauna as follows:

> One of your lots indicates the hitherto unknown presence of the Decorah zone at Kingston. The same zone is thinly represented at Watertown and Threemile Bay, in New York, but there it is separated from the Lowville by the Watertown limestone.
>
> The lot referred to is 5056. Three or four layers are represented in this lot. The youngest is filled with Decorah Bryozoa and plates of a highly characteristic crinoid. The other two or three layers are regarded as belonging near the top of the Lowville or in the Leray.

The Lowville and Leray limestones are present in the upper part of most of the limestone hill sections north and northwest of Kingston. Further west they extend lower in the valleys. They are unknown east of the Rideau canal with the exception of a small patch of the Lowville on Barriefield hill. On the northwest side of Wolfe island this limestone series occupies a narrow belt northwest of the margin of the Trenton limestone.

Trenton Group

Lower Trenton.—The Black River limestones are terminated above by another limestone series characterized by a fauna having many species unknown in the Black River fauna. *Dalmanella rogata* and *Plectambonites sericeus* are conspicuously abundant species in this fauna which represents the Lower Trenton limestone fauna. The lowest beds observed in the Trenton which are 6 or 8 feet above the Black River show beds of thin-bedded, dark grey limestone separated by filmy strata of dark shale. These beds hold an abundance of fossils. The contact of these beds with the Black River has not been observed in this area but it is

[16] Letter of Apr. 17, 1916.

reported to show locally a basal conglomerate[11] and other physical evidence of a disconformity in an adjacent area on the New York side of the St. Lawrence. Only the lower portions of the Trenton beds are found within the area covered by this report. These underlie considerable portions of the western half of Wolfe island. The Lower Trenton as developed on Wolfe island comprises a series of interbedded limestones and calcareous shales having a total thickness that probably does not much exceed 70 feet. The approximate boundary between the Black River and the Trenton is indicated by the base of a low scarp generally 8 or 10 feet high, but indistinct and drift-covered in parts of its course. This abrupt rise just south of the contact of the two horizons is well shown a few hundred yards south of the spring located a mile and a half east of Marysville. This slight rise of the land after the contact is crossed can be traced in a southwesterly direction to the western end of the island.

The best exposures of the Trenton occur along the lake shore cliffs northeast of Bear point on the southeast side of the island. The cliffs expose a section ranging from a thickness of 6 or 8 feet at the eastern end to 18 or 20 feet toward the western end of the exposures. Bluish-grey shale and shaly limestones comprise about one-half of the section here, the remaining beds being limestones from four inches to a foot thick. Some of the thin bands of limestone show distinct cross bedding. At one point a limestone bed was observed that showed abrupt truncation by superjacent beds representing evidently erosion which was contemporaneous with deposition. Fossils abound throughout these beds and include a number of species among which are *Dinorthis pectinella, Plectambonites sericeus* and *Dalmanella rogata.*

Structure

The Ordovician rocks of the Kingston area lie on the southern border of the neck of pre-Cambrian rocks that connects the Adirondack area of schists and gneisses to the southeast with the similar rocks of the Canadian shield to the northwest. This neck indicates the approximate position of the axis of the dominant structural feature of the region, so far as the Paleozoic rocks are concerned. This is the broad geanticlinal arch which crosses the St. Lawrence river in the Thousand Islands area and connects in hour-glass fashion the pre-Cambrian area of the Adirondack mountains with similar rocks in the Haliburton county and Algonquin Park area of Ontario. Away from the axis of this broad and gentle arch the limestones dip in a southerly direction at about 20 feet per mile.

In the majority of outcrops the limestones appear to lie horizontally, but in some localities local synclinal and anticlinal folds are indicated by dips of 5 to 10 degrees. Good examples of these small local folds are seen along the road passing easterly through Barriefield. Sharply inclined beds are seen in the eastern part of the cutting for the highway across Barriefield hill. One and a half miles east of Barriefield the Pamelia limestone shows a dip of 10° in connection with one of these local folds. Another of these sharp local folds gives dips of 10° to 12° at the quarry on the west side of the road south of Rideau station. Many other examples of these local flexures occur in the region. No faults of any magnitude are known in the area.

[11] N.Y. State Mus. Bull. 145, p. 91, 1910.

Appendix II

SYNOPSIS OF THE COMMON FOSSILS OF THE KINGSTON AREA [a]

By ALICE E. WILSON and KIRTLEY F. MATHER [b]

Introduction

The following synoptic list and key to fossils was made with the hope of filling a want that is felt by all beginners in paleontology—the need of a concise and locally adapted reference list and the means of identifying the species in it. It is the desire of the authors to place before the student or local collector the means of ready identification of the more common fossils to be found in the Kingston area. No attempt has been made to give a complete list, and it has been necessary to omit several new species some of which are common.

Fossils are generally scarce in the Pamelia limestone with the exception of ostracods. These small crustaceans are abundant in certain beds. In the Lowville and higher beds of the Black River fossils occur abundantly in most sections.

Certain of the beds of Trenton limestone outcropping on Wolfe island are highly fossiliferous, but the profusion of fossils is one of specimens rather than of species. The abundance of *Rafinesquina alternata, Dalmanella rogata, Plectambonites sericeus, Prasopora simulatrix,* and *Pachydictya acuta* makes it somewhat difficult to find specimens of other forms. Many other fossils, however, will reward the careful and patient collector. The fauna of the Trenton beds is closely similar to that in the Lower Trenton limestone, or "Prasopora zone," in the vicinity of Watertown, Trenton Falls, and Little Falls, New York. It is notably different from that in the "Basal Trenton," or Glen Falls limestone,[1] of the Mohawk valley. Evidently Trenton sedimentation did not begin in this part of Ontario until some time after the opening of the Trenton epoch.

The stratigraphic relations of the faunas treated here have been discussed in preceding pages by Dr. E. M. Kindle. The reader is referred to this paper for stratigraphic details regarding the formations represented by the faunules listed here.

The thanks of the authors are due to Dr. P. E. Raymond for his help in placing the more doubtful species, also to Dr. E. O. Ulrich for the identification of the ostracods and some of the bryozoa.

Synoptic List of Black River Species

STROMATOPOROIDEA.

Stromatocerium sp.

ANTHOZOA.

Columnaria alveolata Goldfuss.
Columnaria halli Nicholson.
Streptelasma profundum (Conrad).
Tetradium cellulosum (Hall).
Tetradium fibratum Safford.
Tetradium syringoporoides Ulrich.

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[a] Published in co-operation with the Canadian Geological Survey.

[b] The pages on the Black River faunas have been prepared by Miss Alice E. Wilson, while the responsibility for the Trenton fauna rests with Dr. K. F. Mather.—Editor.

[1] Ruedemann, Rudolf, New York State Mus. Bull. No. 162, 1912, pp. 22, 69.

CRINOIDEA.

Cremacrinus punctatus Ulrich.

BRYOZOA.

Batostoma winchelli Ulrich.
Hemiphragma irrasum (Ulrich).
Pachydictya fimbriata Ulrich.
Pachydictya occidentalis Ulrich.
Phyllodictya frondosa Ulrich.
Phyllodictya labrinthica (Hall).
Rhinidictya fidelis (Ulrich).
Rhinidictya mutabilis (Ulrich).
Rhinidictya pediculata Ulrich.
Rhinidictya trentonensis (Ulrich).
Solenopora sp.

BRACHIOPODA.

Rafinesquina sp.
Rafinesquina minnesotensis (N. H. Winchester).
Rhynchotrema increbescens Hall.
Strophomena filitexta Hall.
Zygospira recurvirostris Hall.

PELECYPODA.

Cyrtodonta.[2]
Cyrtodonta huronensis Billings.

GASTROPODA.

Hormotoma gracilis (Hall).
Liospira sp.
Lophospira sp.
Raphistoma peracutum Ulrich & Schofield.
Raphistomina cf. *modesta* Ulrich.
Trochonema cf. *umbilicatum* Hall.

CEPHALOPODA.

Endoceras sp.
Gonioceras anceps Hall.
Nanno kingstonensis Whiteaves.
Orthoceras multicameratum Emmons.
Orthoceras recticameratum Hall.

TRILOBITA.

Bathyurus sp. Ulrich.
Bathyurus extans (Hall).
Bathyurus spiniger Hall.
Bumastus milleri (Billings).
Ceraurus pleurexanthemus Green.
Illaenus sp.
Isotalus gigas DeKay.
Onchometopus simplex Raymond and Narraway.
Pterygometopus sp.

OSTRACODA.

Aparchites sp.
Eurychilina sp.
Isochilina subarmata Ulrich.
Leperditella cf. *mundula* Ulrich.
Leperditella tumida Ulrich.
Leperditia fabulites (Conrad).

[2] There are two undetermined species of Cyrtodonta in these beds.

Locality Lists of Black River Fossils[8]

5055—Perth road, quarry north side of Kingston. Upper part of section in Lowville limestone.

Tetradium cellulosum (Hall).
Rafinesquina sp.
Rhynchotrema increbescens Hall.
Zygospira recurvirostris (Hall).
Cyrtodonta cf. *huronensis* Billings.
Raphistomina cf. *modesta* Ulrich.
Orthoceras multicameratum Emmons.
Bathyurus extans (Hall).

5048—Perth road quarry. Lower part of section in Pamelia limestone.

Aparchites sp.
Leperditia sp.
Leperditella sp.

5054—Foot of Fort Henry hill, east side Navy bay. Pamelia limestone.

Bathyurus sp. Ulrich.
Bathyurus spiniger Hall.
Isochilina sp.
Isochilina armata Walcott.
Isochilina subarmata Ulrich M. S.
Leperditia sp.

5050—Quarry half mile north of Fort Henry, east bank of Cataraqui river. Pamelia limestone.

Leperditia fabulites (Conrad).

5053—Portsmouth, west side city asylum. Lowville limestone.

Phyllodictya frondosa? Ulrich.
Tetradium cellulosum Hall.
Leperditella tumida Ulrich.

5049—Railroad cut opposite head of Collins bay. Upper part of Pamelia limestone.

Strophomena filitexta Hall.
Zygospira recurvirostris (Hall).
Cyrtodonta cf. *huronensis* Billings.
Isotelus gigas DeKay.
Pterygometopus sp.
Aparchites sp.
Eurychilina sp.
Isochilina subarmata Ulrich M. S.
Leperditella cf. *mundula* Ulrich.
Leperditia sp.

5056—North of Kingston five miles and half mile southwest of Shannon cross-roads. Upper beds in Leray and Lowville limestones.

Streptelasma profundum (Conrad).
Tetradium cellulosum (Hall).

[8] Numbers prefixed to the localities of this list refer to the locality catalogue of the Canadian Geological Survey.

Tetradium fibratum Safford.
Cremacrinus punctatus Ulrich.
Batostoma winchelli Ulrich.
Hemiphragma irrasum (Ulrich).
Pachydictya fimbriata Ulrich.
Pachydictya occidentalis Ulrich.
Phyllodictya labyrinthica (Hall).
Rhinidictya fidelis (Ulrich).
Rhinidictya mutabilis Ulrich.
Rhinidictya pediculata Ulrich.
Rhinidictya trentonensis (Ulrich).
Solenopora sp.
Rafinesquina minnesotensis (N. H. Winchell).
Rhynchotrema increbescens Hall.
Zygospira recurvirostris (Hall).
Cyrtodonta sp.
Cyrtodonta cf. *huronensis* Billings.
Hormotoma gracilis (Hall).
Liospira sp.
Lophospira sp.
Raphistoma peracutum Ulrich & Scofield.
Trochonema umbilicatum Hall.
Endoceras sp.
Orthoceras recticameratum Hall.
Bumastus milleri (Billings).
Isotelus gigas DeKay.
Onchometopus simplex Raymond and Narraway.
Leperditella tumida Ulrich.
Leperditia fabulites (Conrad).

5047—Locality as above. Lower Beds in Leray and Lowville limestones.

Stromatocerium sp.
Tetradium cellulosum.
Cyrtodonta cf. *huronensis* Billings.
Bathyurus extans Hall.

5052—Wolfe island, southwest of Marysville pier. Lowville limestone.

Tetradium syringoporoides var. n. sp.

5150—Wolfe island, southwest side of Marysville. Upper part of Leray and Lowville limestones.

Columnaria alveolata Goldfuss.
Columnaria halli Nicholson.

5216—Railroad cut at Kingston Mills. Rideau beds.

Nanno kingstonensis Whiteaves.

5217—Four hundred yards northeast of Jackson's mill. Basal Pamelia.

Cyrtodonta sp.
Raphistoma peracutum Ulrich and Scofield.

5218—Five miles northwest of Kingston and half mile north of Jackson's mill. Lowville.

Streptelasma profundum (Conrad).
Rafinesquina sp.
Rafinesquina minnesotensis (N. H. Winchell).
Rhynchotrema increbescens Hall.
Strophomena filitexta Hall.

Zygospira recurvirostris Hall.
Cyrtodonta huronensis Billings.
Raphistoma peracutum Ulrich and Scofield.
Orthoceras recticameratum Hall
Bathyurus extans Hall (Hall).
Bathyurus spiniger (Hall).
Bumastus milleri (Billings).
Ceraurus pleurexanthemus Green.
Illaenus sp.

Kingston.

Gonioceras anceps (Hall).

Key to Black River Fossils

STROMATOPOROIDEA.

A. Massive, composed of dense horizontal and concentric laminae separated by irregular interspaces, perforated by irregular vertical tubes which place the interlaminar spaces in communication but do not go from top to bottom ..... *Stromatocerium.*

ANTHOZOA.

A. Coral simple; calyx funnel-shaped; septa of two orders, primary and secondary; epitheca thin; tabulae present..... *Streptelasma.*
b. Calyx deep; septa denticulated on the edge, not twisted at the centre, three principal septa developed..... *S. profundum* (Conrad).
AA. Compound heads or branching stems of prismatic tubes with well-developed septa.
C. Corallites minute; four primary septa..... *Tetradium.*
d. Coralla massive, hemispherical or flattened diverging tubes; thin slightly rugose walls; lamillae reaching centre of tube. *T. fibratum* Safford.
dd. Irregularly branching bundles of tubes quadrangular or stellate in section ..... *T. cellulosum* (Hall).
ddd. Single tubed form..... *T. syringoporoides* Ulrich.
CC. Generally massive; corallites with alternating large and small septa, complete tabulae and no mural pores..... *Columnaria.*
e. Septa alternating, large ones almost reaching the centre; tabulae horizontal bent down at edge..... *C. alveolata* Goldfuss.
ee. Septa short, denticulated; tabulae complete, often concave or convex but never bent..... *C. halli* Nicholson.

CRINOIDEA.

A. Three primary radials; four basal pieces completely anchylosed; dorso-lateral plates of cup entirely separated by central pieces; ventral area with long and slender ventral tube..... *Cremacrinus.*
b. Body short; centro-dorsal pieces large; entire surface punctuate. *C. punctatus* Ulrich.

BRYOZOA.

A. Zoaria compound; zooecia prismatic; walls thin in axial region becoming thickened in peripheral region; diaphragms numerous; acanthopores abundant; mesopores few or wanting; maculae on the surface.
B. Zoaria irregularly ramose with basal expansion; diaphragms numerous especially in the peripheral region; acanthopores large and abundant; mesopores rather numerous; apertures ovate or circular surrounded by a ring..... *Batostoma.*
c. Branches a little compressed; acanthopores placed on the aperture walls; mesopores sparingly developed; monticules generally wanting; apertures rounded or sub-angular, irregularly arranged. *B. winchelli* Ulrich.

BB. Differs from Batostoma only in having incomplete diaphragms in the peripheral region ..... *Hemiphragma.*

d. Diaphragms remote in axial, more numerous in peripheral region; acanthopores numerous; mesopores in young become solid in maturity; monticules wanting; apertures polygonal, oval when mature ..... *H. irrasum* Ulrich.

BBB. Zoarium spheroidal; zooecia irregularly prismatic and minute; no diaphragms ..... *Solenopora.*

AA. Compound bifoliate zoaria with irregularly dividing branches; apertures arranged longitudinally; non-poriferous border; acanthopores present; mesopores, with diaphragms, become closed on the surface.

E. Zoaria narrow, compressed with parallel sides attached by expanded base; slightly elevated straight or flexuous ridges crowded with blunt spines; apertures subcircular ..... *Rhinidictya.*

f. Edges less acute than usual; non-poriferous border narrow; apertures slightly oblique; longitudinal ridges slight but sharp, containing minute spines ..... *R. fidelis* (Ulrich).

ff. Edges somewhat acute; non-poriferous border very narrow or wanting; apertures narrow; mesopore surface elevated; longitudinal ridges rounded, bearing granules and but slightly elevated.
R. mutabilis (Ulrich).

fff. Small footstalk; branches on one plane, thin sharp edges; non-poriferous border wide and obliquely striated; apertures sunken, outer row larger and oblique ..... *R. pediculate* Ulrich.

ffff. Branches long; non-poriferous border distinct but narrow; apertures comparatively large, outer row oblique; longitudinal ridges slight, without granules; cell walls thin .... *R. trentonensis* (Ulrich).

EE. Irregularly broad or leaf-like branches; long zooecial tubes crossed by complete diaphragms without hemisepta; apertures circular, slightly oblique with lower lip margined ..... *Phyllodictya.*

g. Flattened, flexuous stems; cells oval arranged in quincunx order.
P. labyrinthica (Hall).

gg. Aperture oblique, more or less regularly arranged in intersecting diagonal series. Minute papillae present ..... *P. frondosa* Ulrich.

EEE. Zoaria irregularly wide or undulating leaf-like branches; narrow non-poriferous border obliquely striate; diaphragms few; small maculae; aperture elliptical; interspaces forming a peristome about aperture or in longitudinal ridges ..... *Pachydictya.*

h. Non-poriferous border wide, sharp, thin, extremely wavey; apertures broadly elliptical, two or three outer rows irregular, usually oblique; striae formed of papillae ..... *P. fimbriata* Ulrich.

hh. Ramose or subpalmate; non-poriferous border sharp, narrow, smooth or finely striate; aperture ovate; sometimes a series of smooth solid spots, particularly below the point of bifurcation.
P. occidentalis Ulrich.

BRACHIOPODA.

A. Shell, concavo-convex, never strongly biconvex, averaging about one to one and a half inches in the widest dimension; cardinal area straight; hinge line long, usually forming the greatest width of shell; radiating striae alternating in size, crossed by fine concentric growth lines.

B. Shell normally concavo-convex; pedicle valve convex, brachial valve concave; muscular area faintly delimited ..... *Rafinesquina.*

c. Size somewhat smaller than *Rafinesquina alternata;* surface of pedicle valve convex with suddenly deflected margins beyond the visceral region ..... *R. minnesotensis* (N. H. Winchell).

BB. Shell resupinate; cardinal area conspicuous; pedicle valve convex at the umbo, becoming rapidly concave; brachial valve flat or concave at the umbo, becoming convex; muscular area deeply excavated.
Strophomena.

d. Cardinal extremities angular and deflected, cardinal area narrow, vertical; conspicuous deltidium; pedicle valve often with an ill-defined sinus; brachial valve sometimes with broadly rounded median fold; in some specimens oblique wrinkles present along cardinal margin ..... *S. filitexta* Hall.

AA. Shell rostrate, biconvex; entirely covered with plications; sinus and fold present.

E. Shell convex, becoming gibbous with age; cardinal area absent; beaks closely incurved; sinus and fold prominent; radiating striae coarse.
Rhynchotrema

f. Shell ovoid or subtriangular; pedicle valve convex at umbo deep sinus with three to four plications; brachial valve more convex, with corresponding fold; plications never subdivide; transversely marked by imbricating lines.....*R. increbescens* (Hall).

EE. Shell small; beaks acute and pedicle beak gracefully incurved; fine but sharp radiating striae.....*Zygospira.*

g. Shell subcircular; length slightly exceeding width; surface with about twenty-four simple striae.....*Z. recurvirostris* (Hall).

PELECYPODA.

A. Shell ovate to subcircular; moderately ventricose; beaks prominent, incurved, situated about anterior third of shell; concentric growth lines; hinge plate strong, nearly straight; no lunule nor escutcheon; 2 to 4 cardinal teeth, 2 to 3 posterior teeth.....*Cyrtodonta.*

b. Transversely oval, anterior and posterior extremities rounded; greatest tumidity extending from the umbones obliquely towards the posterior ventral margin.....*C. huronensis* Billings.

GASTROPODA.

A. Spire depressed conical or flat; sutures close; umbilicus usually present.

B. Peripheral slit band present; aperture deeply notched.

C. Volutions sub-rhomboidal in section, sharply rounded at periphery, convex below, sometimes angular at edge of umbilicus; band wide, on narrow outer edge of whorl; markings delicate fine transverse lines bending strongly backwards on apical side to peripheral band then forward on lower side .....*Liospira.*

BB. Peripheral slit band absent; aperture with shallow notch.

D. Volutions triangular in section, sharply angular, generally thin at periphery; sigmoid lines of growth on upper side cut by raised line, below turned forward first then back into umbilicus.
Raphistoma.

e. Whorl flat above, rounded below; margin narrowly rounded.
R. peracutum Ulrich.

DD. Volutions subrhomboidal in section, carina projecting over the slightly impressed suture; sutural half of curve of lips convex, outer half concave; lines of growth distinct, not interrupted on upper side.
Raphistomina.

f. Peripheral edge turns distinctly upward; lines of growth faint except in last whorl; umbilicus small.....*R. modesta* Ulrich.

AA. Spires elevated.

G. Whorls rounded or obscurely angular.

H. Shell elongate; apical angle acute; no umbilicus; aperture acuminate, outer lip with a broad deep V-shaped notch; peripheral band sometimes obscure, flat or concave, outlined by raised lines; surface markings growth lines only which sweep backward towards the band above and below.....*Hormotoma.*

i. Shells slender; whorls rather loosely coiled; slight angulation; apical angle very constantly about 18°; lines of growth fine.
H. gracilis (Hall).

GG. Whorls angular with distinct carina.

J. Shell more or less elevated; umbilicus small; band obtusely rounded, more or less trilineate, median line heavier; outer lip notched, inner lip thickened and twisted; surface markings parallel with apertural edge, occasionally cancelled by fine spiral lines.
Lophospira.

JJ. Shell turbinate; umbilicus rather large; band wide, vertical, marked off above and below by carina; aperture very oblique; lines of growth pass obliquely backward from above, vertical or opposite on the band, following outer lip in lower part.....*Trochonema.*

k. Carina dividing whorl above band, between suture and carina flat, between carina and band concave; carina between band and umbilicus preserving a median position; surface markings obscure except on last whorl.....*T. umbilicatum* (Hall).

CEPHALOPODA.

A. Shell straight, conical; body chamber large; siphuncle central or excentric, sometimes widening in the chambers; sutures simple and at right angles to the long axis of the shell; surface smooth ornamented by striae, or annulated ..... *Orthoceras.*

b. Shell extremely elongated, slender, tapering; siphuncle ventral; surface smooth or slight undulations; camera varying in depth. *O. multicameratum* Emmons.

bb. Shell tapering; siphuncle cylindrical somewhat excentric; septa passing obliquely from outside to siphuncle...*O. recticameratum* (Hall).

AA. Shell straight, compressed, with projecting angles; septa curved; siphuncle ventral and beaded .....*Gonioceras.*

c. Shell smooth or finely striated; elongated, tapering rather rapidly; projecting angles very acute; septa crowded.....*G. anceps* Hall.

AAA. Shell straight, cylindrical in section.

D. Siphuncle excentric, cylindrical, gradually enlarging, often ridged obliquely by the septa; surface not annulated.....*Endoceras.*

DD. Siphuncle with gibbous expansions at the apex.....*Nanno.*

e. Siphuncle expansion ceases abruptly, long slender upper portion obliquely crossed by annulations.....*N. kingstonensis* Whiteaves.

TRILOBITA.

A. Genal angles or spine borne by free cheeks.

B. Glabella of cephalon and axis of pygidium distinctly defined.

C. Cephalon longer than pygidium; glabella single, its sides straight, glabella furrows nearly or quite obsolete; eyes long and close to glabella; free cheeks with a concave border; hypostoma not forked; thorax nine segments; pygidium broad; axial lobe convex and prominent. *Bathyurus.*

d. Frontal border of cephalon narrow; pygidium very convex, axial lobe with two distinct rings, a third obscure; pleura four broad segments. *B. extans* (Hall).

dd. Frontal border of cephalon turning up along margin; glabella with two indistinct furrows, and occipital spine; three distinct furrows on the axial lobe of pygidium a fourth and fifth obscure, the third bearing a spine; on the pleura a row of tubercles parallel to the axial lobe.....*B. spiniger* Hall.

BB. Glabella of cephalon and axis of pygidium not well defined.

E. Body trilobed; oval; cephalon and pygidium about equal in size.

F. Concave border on cephalon and pygidium; anterior margin of cephalon rather sharply rounded; glabella nearly smooth; free cheeks large; hypostoma deeply forked posteriorly; axial lobe very broad; sedmentation of pygidium obsolete at maturity.....*Isotelus.*

g. Cephalon and pygidium subtriangular; surface punctate; eyes prominent; middle lobe of thorax very broad.....*I. gigas* DeKay.

FF. Margin of cephalon and pygidium rounded; doublure rounded; median tubercle on glabella; axial lobe about one third of whole width and in pygidium ending a little more abruptly than the other portions .....*Onchometopus.*

h. Glabella flat, neck furrow absent; pleura of thorax with shallow grooves; no pleura on pygidium..*O. simplex* Raymond & Narraway.

FFF. Cephalon and pygidium large, semicircular, convex; glabella smooth, indistinct, two dorsal furrows; eyes large.....*Illaenus.*

EE. Body not trilobed except slightly on the cephalon.

I. Cephalon convex with slightly impressed furrows; eyes remote; ten thoracic segments; pygidium smooth.....*Bumastus.*

j. Form broad and short; two obscure indentations between the eyes; nine thoracic segments.....*B. milleri* (Billings).

ÁA. Genal angles borne by fixed cheeks, glabella enlarging anteriorly, furrows distinct.

K. Glabella tumid; eyes large conspicuous; pygidium semicircular and entire. *Pterygometopus.*

KK. Glabella pustulose; eye small, distant from glabella; pygidium small with segments ending in spines of unequal length.....*Ceraurus.*

l. Flaring spines on genal angles; surface of cephalon covered with pits and tubercles; glabella very convex nearly square in front, three pairs of glabellar furrows; pygidium small and short with two large spines.....*C. pleurexanthemus* Green.

OSTRACODA.

A. Straight hinge line, without sulcus.
B. Valves unequal and overlapping.
C. Left valve overlapping the right, bearing a groove into which right valve fits; surface smooth; obscure flattening on dorsal half of valve. *Leperditella.*
d. Valves rather short, posterior and much wider; tumid; surface punctate.....*L. tumida* (Ulrich).
dd. Less high than *L. tumida*, more elongate.....*L. mundula* (Ulrich).
CC. Right valve overlapping; carapace more or less convex, often large, oblique backward swing; papillae present marking the overlapping limit; eye spot present; sunken muscle spot.....*Leperditia.*
e. Ends obliquely truncated above, extremities almost equally angular; eye spot hardly distinguishable; punctae minute. *L. fabulites* (Conrad).
BB. Valves convex, equal.
G. Large; eye tubercle present.....*Isochilina.*
h. Extremities angular; a prominent spine projects from point of greatest convexity, curving towards anterior.....*I. armata* Walcott.
GG. Small; surface smooth without any tubercle.....*Aparchites.*
AA. Straight hinge line with a broad dorsal depression.
I. Suboval or nearly circular; node just behind sub-central sulcus; broad flange around valves sometimes radially striated.....*Eurychilina.*

Synoptic List of Trenton Fossils

Locality List

Station 222. Lower five feet of Trenton limestone, four miles southwest from Marysville, Wolfe island. Lot 2, north, Con. III.

Station 223. Trenton limestone, probably ten or twelve feet above the base of the formation, one and one-half miles southeast from Marysville, Wolfe island. Lot 1, north, Con. VIII.

Station 224. Lower seven feet of Trenton limestone, immediately south of Cold Spring corner, Wolfe island. Lot 3, Con. IX.

Station 226. Trenton limestone, probably twenty or thirty feet above its base, along southern shore of Bear point at southwestern extremity of Wolfe island.

Faunal List

	Stations.			
PORIFERA.	222	223	224	226
Receptaculites occidentalis Salter	..	x	..	..
ANTHOZOA.				
Streptelasma corniculum Hall	..	..	..	x
BRYOZOA.				
Prasopora simulatrix Ulrich	x	..	x	x
Eridotrypa aedilis (Eichwald)	..	..	x	x
Eridotrypa aedilis minor (Ulrich)	..	..	x	x
Eridotrypa exigua Ulrich	x	..	..	..
Hallopora ampla (Ulrich)	..	..	x	..
Hallopora obliqua n.sp.	..	..	x	..
Hallopora varia n.sp.	..	..	..	x
Batostoma winchelli Ulrich	..	..	x	x
Stictoporella angularis Ulrich	..	..	x	..
Pachydictya acuta (Hall)	x	..	x	x

Faunal List.—Continued

	Stations.			
BRACHIOPODA.	222	223	224	226
Orthis tricenaria Conrad	..	x	..	x
Dalmanella rogata (Sardeson)	x	x	x	x
Dinorthis pectinella (Emmons)	..	..	..	x
Plectambonites sericeus (Sowerby)	x	..	x	x
Rafinesquina alternata (Emmons)	x	x	x	x
Triplecia extans (Hall)?	..	x	..	..
Camarella ambigua (Hall)	..	x	..	..
Parastrophia hemiplicata (Hall)	..	..	..	x
GASTROPODA.				
Sinuites cancellatus (Hall)	x	x	..	..
Liospira vitruvia (Billings)	..	x	..	x
Hormotoma gracilis (Hall)	x	..	..	x
Hormotoma trentonensis Ulrich and Schofield	..	..	..	x
Conularia trentonensis multicosta Ruedemann	..	..	..	x
CEPHALOPODA.				
Orthoceras junceum Hall?	x	..	..	x
TRILOBITA.				
Isotelus gigas DeKay	x	..	..	..
Bumastus sp.	..	x	..	..
Calymene senaria Conrad	x	..	..	..
Ceraurus dentatus Raymond and Barton	x	..	..	..
Ceraurus pleurexanthemus Green	x	x	..	..

Descriptive Key of Trenton Fossils

PORIFERA.

Spherical to platter-shaped bodies with a central closed cavity; calcareous wall composed of five-rayed spicules ..... *Receptaculites.*

Body consisting of a broad flattened disc with a small funnel-shaped central depression above, corresponding to the narrow projecting base of attachment on the under side; all rows curving strongly as they radiate from the centre; canals numerous in plates of upper or inner surface; prominent central knobs on head plates of outer or under surface ..... *R. occidentalis* Salter.

ANTHOZOA.

Coral simple; turbinate, conical, or cylindrical. Septa numerous, bilaterally symmetrical in arrangement; tabulae completely developed; dissepiments not abundant.

Pseudo-columella formed by union of edges of longer septa; cardinal septum may be recognized on exterior by system of pinnately diverging costal ridges; tabulae few, sometimes absent altogether ..... *Streptelasma.*

Corallum conical, more or less curved; calyx not very deep; septa alternately large and small, from 45 to 60 of the former in adult stage; cardinal and counter septa long and prominent, alar septa short; larger septa twisted at their inner edges to form pseudo-columella ..... *S. corniculum* Hall.

BRYOZOA.

Zoarium massive, free; hemispherical, discoidal, or irregular.

Zooecial tubes, prismatic or cylindrical, thin-walled, partially separated from each other or completely isolated by smaller angular mesopores; cystiphragms in all zooecial tubes; diaphragms abundant in mesopores ..... *Prasopora.*

Zooecial tubes varying from circular to polygonal, diameter about 0.25 mm., acanthopores absent; about 12 cystiphragms in space of 2 mm. along zooecial tubes; diaphragms in mesopores generally about 14 in 1 mm., but varying in number up to 18 or 19 in that distance ..... *P. simulatrix* Ulrich.

Zoarium ramose, composed of bifurcating branches, sometimes anastomosing, growing upward from an attachment to some foreign object. Ordinarily found as small fragments.

Branches bifoliate, composed of two layers of zooecia growing back to back, generally with an elongate oval cross-section.

Branches narrow, with acute parallel margins and a non-poriferous margin; diaphragms present ..... *Pachydictya.*

Branches ordinarily from 2.5 to 3.0 mm. in width, dividing dichotomously at intervals of 10 to 20 mm.; zooecial apertures elliptical, arranged in definite longitudinal rows separated by faint longitudinal ridges, from 7 to 10 rows on each branch..... *P. acuta* (Hall).

Branches poriferous throughout entire width; untabulated mesopores present between elliptical zooecial apertures..... *Stictoporella.*

Branches from 1.5 to 3.0 mm. wide; zooecial apertures separated by thick ridge-shaped walls and arranged in moderately regular, curved, diagonally intersecting series, about 9 in 2.5 mm.; mesopores comparatively few, entirely absent on parts of surface but always present near margins.
S. angularis Ulrich.

Branches radiate, circular or broadly oval in cross-section, zooecia growing in all directions from central axial region. May be safely differentiated only by means of thin sections examined under the microscope.

Zooecial tubes with thin walls, varying according to number of mesopores from oval to polygonal in outline in tangential sections. In longitudinal sections, zooecial walls are thin and flexuous in axial region, more or less thickened in peripheral; diaphragms strong, horizontal, complete, more abundant in peripheral than in axial region. In transverse sections, tubes in axial region appear in two sets, one larger than the other.

Acanthopores abundant ..... *Batostoma.*

Branches generally about 5 mm. in diameter; surface without monticules; apertures rounded or subangular, about 10 or 11 in 3 mm.; mesopores never as numerous as zooecia; diaphragms abundant in proximal ends of zooecial tubes, more distant (from one to three diameters) in axial region, again abundant in peripheral portion where tubes bend rather abruptly toward surface..... *B. winchelli* Ulrich.

Acanthoropes absent ..... *Hallopora.*

Branches generally about 5 or 6 mm. in diameter; surface without monticules; apertures variable in outline, about 9 in 3 mm.; tubes curving rather abruptly toward surface with diaphragms very abundant (7 or 8 in 0.5 mm.) in and beyond the curve..... *H. ampla* (Ulrich).

Branches slender, 2 to 4 mm. in diameter; surface without monticules; apertures polygonal, about 11 in 3 mm.; zooecial tubes enter peripheral region without pronounced curvature; outer two or three diaphragms more closely spaced than those in axial region ..... *H. obliqua* n. sp.

Branches 5 to 8 mm. in diameter, bifurcating at frequent intervals; surface without monticules; apertures angular, about 10 in 3 mm.; diaphragms in proximal portion of tubes and in mesopores at distances approximating the diameter of tube, in enlarged mesial portion of tubes distant somewhat more than a diameter from each other, and one-third to one-half the diameter apart in peripheral region where tubes bend somewhat abruptly outward ..... *H. varia* n. sp.

Zooecial tubes with thick walls; diaphragms rare or even absent in axial region, but always present and closely spaced in the turn from axial into narrow peripheral region; acanthopores small, never numerous, sometimes absent; mesopores varying in number..... *Eridotrypa.*

Branches generally 3 to 5 mm. in diameter; diaphragms irregularly spaced in axial region, but averaging about twice their diameter apart, increasing in number in peripheral region where walls are greatly thickened.
E. aedilis (Eichwald).

Similar to last but diaphragms absent throughout greater part of axial region and with somewhat smaller branches..... *E. aedilis minor* (Ulrich).

Branches very slender, generally less than 1 mm. in diameter.. *E. exigua* Ulrich.

BRACHIOPODA.

Hinge line long and straight, more than one-third the greatest width of shell; cardinal area well developed.

Shell concavo-convex; surface radially striate.

Shell large, semi-oval, brachial valve concave, pedicle valve convex; striae alternating in size..... *Rafinesquina.*

Broadly semi-oval in outline, about 30 mm. long, and 40 mm. wide (along hinge line); alternation of striae very pronounced on both valves.
E. alternata (Emmons).

Shell small, wider than long, greatest width along hinge line; brachial valve concave, pedicle valve convex; stria very fine.....*Plectambonites.*

Length about 12 mm., width about 20 mm.; inconspicuous fold and sinus frequently developed; striae alternating in strength, surface usually silky.
P. sericeus (Sowerby).

Shell plano-convex or biconvex; surface radially plicate or striate.

Brachial valve plane or very slightly convex.

Cardinal area of pedicle valve elevated and somewhat incurved; surface covered with strong, sharp, and comparatively few plications which are almost invariably simple.....*Orthis.*

Shell of medium size, 12 to 14 mm. long, 17 to 19 mm. wide (along hinge line); cardinal area unusually high; surface marked by 35 to 40 simple angular plications.....*O. tricenaria* Conrad.

Pedicle valve elevated and arched over the cardinal area; surface covered with rounded bifurcating striae or fine plications which curve conspicuously from umbo toward lateral margins; dental lamellae well developed.
Dalmanella.

Shell less than medium size, length and width subequal and generally falling between 16 and 18 mm.; surface carrying fine plications rather than striae.....*D. rogata* (Sardeson).

Brachial valve strongly convex, pedicle valve elevated at umbo but becoming gradually depressed and finally flat or concave anteriorly; dental lamellae surrounding a subquadrate muscular area, cardinal process erect.....*Dinorthis.*

Shell of medium size, length and width between 20 and 25 mm.; surface marked with 22 to 30 prominent plications separated by flat interspaces.
D. pectinella (Emmons).

Hinge line short, less than one-third the greatest width of shell; cardinal area absent or very limited; shell rostrate.

Fold and sinus present; plications present near anterior margin but absent from umbo.

Shell subcircular, brachial valve the larger and more convex, its beak projecting conspicuously beyond that of pedicle valve.....*Parastrophia.*

Shell less than medium size, subglobose, width about 18 mm., length about 15 mm., thickness often equal to length; surface bearing 3 or 4 plications on either side of fold and sinus, 2 or 3 plications in the sinus, and 3 or 4 in the fold, all strong toward the front but fading away entirely toward the umbo .....*P. hemiplicata* (Hall).

Shell subtriangular or subquadrate, brachial valve more convex than pedicle, plications few and low; spondylium well defined, cruralium very small and supported by a long septum.....*Camarella.*

Shell small to medium, distinctly trilobate; plications in fold and sinus varying from 0 to 4, generally somewhat obscure; lateral slopes typically smooth .....*C. ambigua* (Hall).

Fold and sinus present; surface without plications.

Shell trilobate, transverse; hinge-line straight and short, cardinal area low and well defined; brachial valve very convex, pedicle valve shallow; cardinal process long, erect, and bifurcate.....*Triplecia.*

Shell small to medium, subrhomboidal in outline; fold and sinus prominent and rounded, somewhat produced in front; cardinal line more extended in pedicle than in brachial valve.....*T. extans* (Hall).

GASTROPODA.

Shell coiled symmetrically in a single plane.

Aperture not abruptly expanded; outer lip and lines of growth dorsally sinuate; slit and band absent.

Umbilicus closed; dorsum convex but not carinate; outer lip bilobate.....*Sinuites.*

Surface of shell (very rarely preserved) cancellated by exceedingly fine revolving and growth lines; dorsal region of last whorl rounded; sinus in outer lip U-shaped and bordered by rounded apertural lobes.
S. cancellatus (Hall).

Shell coiled unsymmetrically in a spiral form.

Spire low, depressed conical or nearly flat.

Volutions subrhomboidal in section, sharply rounded at periphery, convex below; sutures very close, scarcely distinguishable; aperture deeply notched; slit band wide but very inconspicuous.....*Liospira.*

Shell about 25 mm. in diameter, height about half the width; umbilicus open, from one-fourth to one-third as wide as diameter of shell; umbilical margin distinctly angular.....*L. vitruvia* (Billings).

Spire elevated.

Shell elongate, whorls numerous and rounded or subangular, umbilicus closed; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with broad and deep V-shaped notch; surface marked with lines of growth only .....*Hormotoma.*

Shell small, slender, 20 to 33 mm. high, with apical angle of 18°; volutions about 14, rather loosely coiled, rounded with a very slight angulation generally present just below the middle.....*H. gracilis* (Hall).

Shell of medium size, 20 to 45 mm. high, with apical angle of about 45°; volutions 6 or 7, rather closely wound, sometimes a little flattened in the upper half .....*H. bellicincta* (Hall).

Shell large, 30 to 100 mm. high, with apical angle of about 35°; volutions 7 or 8, uniformly convex from suture to suture.

H. trentonensis Ulrich & Scofield.

CONULARIDA.

Paleozoic forms of doubtful systematic position, resembling some of the recent pteropods, but probably to be regarded as a parallel rather than as an identical group.

Shell calcareous, thin-walled, rectilinear, elongate-conical, rectangular in cross section, with usually sharp edges; each of the lateral faces transversely striated or ribbed, divided into longitudinal halves by a superficial groove, corresponding internally to a median ridge .....*Conularia.*

Apical angle 18° to 20°; surface ornamented by transverse ridges crossed by closely-set longitudinal bars, 6 to 9 ridges in 5 mm. .....*C. trentonensis* Hall.

The same, but with 15 to 17 ridges in 5 mm..*C. trentonensis multicosta* Ruedemann.

CEPHALOPODA.

Shell external, chambered, sutures simple or gently lobed; septa concave, siphonal funnels of greater or less length.....Order *Nautiloidea.*

Shell straight, cylindrical, siphuncle small.

Shell gently tapering, surface smooth or ornamented only by growth lines; siphuncle centren or nearly so.....*Orthoceras.*

Shell slender, 5 to 15 mm. in diameter; septa separated by distances equal to one-fourth to one-third the diameter; siphuncle small, centrally located, circular .....*O. junceum* Hall.

TRILOBITA.

Facial sutures intercepting posterior margin of cephalon, free cheeks bearing genal angle; compound paired eyes on free cheeks.....Order *Opisthoparia.*

Cephalon and pygidium large and subequal; eyes prominent; eight thoracic segments; doublure of cephalon with a median vertical suture.....Family *Asaphidae.*

Depressed or concave border on cephalon and pygidium, both of which are smooth; axial lobe wide, depressed.....*Isotelus.*

Cephalon and pygidium subtriangular, about three-fourths as long as wide; adult lacking genal spines.....*I. gigas* DeKay.

Cephalon and pygidium large, convex, nearly smooth, and without concave border; axial lobe of pygidium short or not recognizable.....Family *Illaenidae.*

Body not trilobed, except very slightly on cephalon.....*Bumastus.*

Body large, 60 to 80 mm. long; cephalon and pygidium 35 to 50 mm. wide.....*B. billingsi* Raymond and Narraway.

Body small, 20 to 25 mm. long; cephalon and pygidium about 20 mm. wide; median eye present near posterior margin of cephalon.

B. bellevillensis Raymond and Narraway.

Facial sutures intercepting lateral margins of cephalon, genal angles on fixed cheeks; compound paired eyes generally present on free cheeks.....Order *Proparia.*

Free cheeks narrow, the facial sutures cutting margin almost exactly in the genal angles .....Family *Calymenidae.*

Glabella prominent, narrowing anteriorly, lateral furrows well developed, non-pustulose; pygidium short, semicircular .....*Calymene.*

Anterior extension of cephalon narrow and not abruptly concave; pygidium with grooved lateral segments.....*C. senaria* Conrad.

Free cheeks small, but not encroaching upon the genal angles; pygidium ornamented with marginal spines .....Family *Cheiruridae.*

Glabella prominent, enlarging anteriorly, pustulose; posterior glabellar furrows short and sloping gently backward, basal lobes quadrangular.....*Ceraurus.*
Genal spines divergent, eyes in front of the mid-length of cephalon, glabellar expansion very slight.....*C. pleurexanthemus* Green.
Genal spines long, eyes behind the mid-length of cephalon; two pairs of short spines on pygidium between one pair of long spines.
C. dentatus Raymond and Barton.

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Tetradium fibratum Safford—Safford, Amer. Jour. Sci. Arts, 2nd ser., XXII, p. 237, fig. 2, 1856; Lambe (part) Cont. Can. Pal. G. S. C., IV, pt. 1, p. 93, pl. 2, fig. 5, 1899.

Tetradium syringoporoides Ulrich—Ulrich, Folio U. S. Geol. Surv. 170, p. 58, 1910; Bassler, Bull. Virginia Geol. Surv. 2a, pl. 4, fig. 2, 1909.

STROMATOPOROIDEA.

Stromatocerium—James, Jour. Cincinnati Soc. Nat. Hist., IX, p. 252, 1886; Parks, Univ. Toronto Studies Geol. Ser., No. 7, p. 8, 1910.

CRINOIDEA.

Cremacrinus—Ulrich, Ann. Rep. Geol. Nat. Hist. Minnesota, XIV, p. 107, 1886.

Cremacrinus punctatus Ulrich—Ulrich, Ann. Rep. Geol. Nat. Hist. Minnesota, XIV, p. 107, fig. 1, 1886.

BRYOZOA.

Batostoma—Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, p. 154, 1882.

Batostoma winchelli (Ulrich)—Ulrich, Geol. Minnesota, Pal., III, p. 295, pl. 26, fig. 33-37, pl. 27, fig. 1-6, 1893.

**Eridotrypa*—Ulrich, Geol. Minnesota, Pal., III, p. 264, 1893.

**Eridotrypa aedilis* (Eichwald)—Ulrich (*E. mutabilis*), Geol. Minnesota, Pal., III, p. 265, pl. 26, figs. 22-28, 31, 32, 1893; Bassler, Bull. U. S. Nat. Mus., 77, pp. 242, 244, pl. 4, figs. 5, 5a, figs. 137, 138, 1911.

**Eridotrypa aedilis minor* (Ulrich)—Ulrich (*E. mutabilis* var. *minor*), Geol. Minnesota, Pal., III, p. 266, pl. 26, figs. 20, 21, 29, 30, 1893; Bassler, Bull. U. S. Nat. Mus., 77, p. 245, fig. 139, 1911.

**Eridotrypa exigua* Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 266, pl. 26, figs. 17-19, 1893.

**Hallopora*—Bassler, Bull. U. S. Nat. Mus., Pal., 77, pp. 325, 326, 1911; Zittel-Eastman, Textb. Pal. p. 337, 1913.

[3] References to Trenton species are starred.*
" " " and Black River species are marked with a dagger.†
" " Black River species are not specially marked.

**Hallopora ampla* (Ulrich)—Ulrich (*Callopora ampla*), Geol. Minnesota, Pal., III, p. 281, pl. 23, figs. 13-15, 18-20, 22, 23, 27, 28, 1893.

Hemiphragma—Ulrich, Geol. Minnesota, Pal., III, p. 299, 1893.

Hemiphragma irrasum (Ulrich)—Ulrich, 14th Ann. Rep. Geol. Nat. Hist. Minnesota, p. 94, 1886; Ulrich, Geol. Minnesota, Pal., III, pt. 1, p. 299, pl. 24, fig. 5-19, 1893.

Pachydictya—Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, p. 152, 1882; Ulrich, Geol. Minnesota, Pal., III, p. 145, 1893.

**Pachydictya acuta* (Hall)—Ulrich, Geol. Minnesota, Pal., III, p. 155, pl. 8, figs. 11-17, pl. 19, fig. 7, 1893.

Pachydictya fimbriata Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 152, pl. 8, fig. 28-34; pl. 9, fig. 13, 14, 1893.

Pachydictya occidentalis Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 151, pl. 8, fig. 20-27; pl. 9, fig. 6-10, 1893.

Phyllodictya—Ulrich, Geol. Minnesota, Pal., III, p. 141, 1893.

Phyllodictya frondosa Ulrich—Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, p. 174, pl. 8, fig. 11-11b, 1882; Geol. Minnesota, Pal., III, p. 142, 1893.

Phyllodictya labrinthica Hall—Hall, Pal. New York, I, p. 50, pl. 12, fig. 8a, b and wood cut on p. 50, 1847.

Prasopora—Nicholson and Etheridge, Ann. Mag. Nat. Hist., 4th ser., XX, p. 388, 1877; Ulrich, Geol. Minnesota, Pal., III, p. 244, 1893.

**Prasopora simulatrix* Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 245, pl. 16, figs. 1-10, 1893.

Rhinidictya—Ulrich, Geol. Minnesota, Pal., III, p. 124, 1893.

Rhinidictya fidelis (Ulrich)—Ulrich, 14th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 68, 1886; Geol. Minnesota, Pal., III, p. 134, pl. 6, fig. 7-7b, 8, 1893.

Rhinidictya mutabilis (Ulrich)—Ulrich, Geol. Minnesota, Pal., III, p. 125, pl. 6, fig. 1-6, 12, 13; pl. 7, fig. 10-23, 25-28; pl. 8, fig. 1-3, 1893; Sardeson, Jour. Geol., IX, p. 155, pl. B, 1901.

Rhinidictya pediculata Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 137, pl. 7, fig. 1-5, 1893.

Rhinidictya trentonensis (Ulrich)—Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, p. 167, pl. 6, fig. 15, 15a, 1882; Geol. Minnesota, Pal., III, p. 135, pl. 6, fig. 14-18; pl. 7, fig. 6-9, 1893.

Solenopora—Nicholson, Geol. Mag., dec. 3, V, p. 19, 1888.

**Stictoporella*—Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, pp. 152, 169, 1882; Geol. Minnesota, Pal., III, p. 179, 1893.

**Stictoporella angularis* Ulrich—Ulrich, Geol. Minnesota, Pal., III, p. 182, pl. 11, figs. 1-3, 6, 8-11, 1893.

BRACHIOPODA.

**Camarella* Billings—Canadian Nat. Geol., IV, p. 301, 1859; VI, p. 316, 1861; Hall and Clarke, Pal. New York, VIII, pt. 2, p. 219, 1893.

**Camarella ambigua* (Hall)—Hall (*Atrypa ambigua*), Pal. New York, I, p. 143, pl. 33, figs. 8, 9, 1847.

**Dalmanella*—Hall and Clarke, Pal. New York, VIII, pt. 1, pp. 205, 223, 1892.

**Dalmanella rogata* (Sardeson)—Hall (*D. testudinaria*), Pal. New York, I, p. 117, pl. 32, fig. 1; p. 288, pl. 79, fig. 4, 1847; Whiteaves, Pal. Foss. Geol. Survey, Canada, III, pt. 2, p. 121, 1895; III, pt. 3, pp. 177, 241, 1897; Raymond, Can. Geol. Surv., Summ. Rept. for 1912, pp. 344-347, 1914.

**Dinorthis*—Hall and Clarke, Pal. New York, VIII, pt. 1, pp. 195-222, 1892.

**Dinorthis pectinella* (Emmons)—Hall, Pal. New York, I, p. 123, pl. 32, fig. 10, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 154, pl. 9, fig. 29, 30, 1903.

**Orthis*—Dalman, Kongl. Svenska Vet. Akad. Handl., pp. 93, 96, 1828; Hall and Clarke, Pal. New York, VIII, pt. 1, p. 192, 1892.

**Orthis tricenaria* Conrad—Hall, Pal. New York, I, p. 121, pl. 32, fig. 8, 1847; Grabau and Shimer, N. A. Index Fossils, I, p. 250, fig. 301, a-c, 1907.

**Parastrophia*—Hall and Clarke, Pal. New York, VIII, pt. 2, p. 221, 1893.

**Parastrophia hemiplicata* (Hall)—Hall, Pal. New York, I, p. 144, pl. 33, fig. 10, 1847; Wilson, Geol. Surv. Canada Mus. Bull. 2, pp. 1-10, pl. 1, figs. 1-34, 1914.

**Plectambonites*—Pander, Beitrage sur Geognosie des Russ. Reiches, p. 90, pl. 3, figs. 8, 16; pl. 28, fig. 19, 1830; Hall and Clarke, Pal. New York, VIII, pt. 1, pp. 236, 295, 1892.

**Plectambonites sericeus* (Sowerby)—Hall, Pal. New York, I, pp. 110, 287, pl. 31B, fig. 2; pl. 79, fig. 3, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 149, pl. 9, figs. 14, 15, p. 216, pl. 16, figs. 2, 3, 1903.

Rafinesquina—Hall and Clarke, Pal. New York, VIII, pt. 1, p. 281, 1892; Grabau and Shimer, N. A. Index Fossils, I, p. 211, 1907.

**Rafinesquina alternata* (Emmons)—Hall, Pal. New York, I, pp. 102, 286, pl. 31, fig. 1; pl. 31A, fig. 1; pl. 79, fig. 2, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 148, pl. 9, figs. 12, 13, 1903.

Rafinesquina minnesotensis (N. H. Winchell)—N. H. Winchell, 9th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 120, 1881; Winchell and Schuchert, Geol. Minnesota, Pal., III, p. 401, pl. 31, fig. 25-29, 1893.

Rhynchotrema—Hall and Clarke, 13th Ann. Rep. N.Y. State Geol., p. 825, 1893; Winchell and Schuchert, Geol. Minnesota, Pal., III, p. 458, 1893.

Rhynchotrema increbescens Hall—Hall (*Atrypa increbescens*), Pal. New York, I, p. 146, pl. 33, fig. 13a-1, 1847; Winchell and Schuchert (*Rhynchotrema inaequivalvis*), Geol. Minnesota, Pal., III, p. 459, pl. 34, fig. 12-14, 24, 25, 1893.

Strophomena—Winchell and Schuchert, Geol. Minnesota, Pal., III, p. 384, 1893; Grabau and Shimer, I, p. 222, 1907.

Strophomena filitexta (Hall)—Hall (*Leptaena filitexta*), Pal. New York, I, p. 111; pt. 31B, fig. 3a-c, 1847; Weller (*Strophomena incurvata*), Geol. Surv. New Jersey, Pal., III, p. 150, pl. 9, fig. 16, 17, 1903.

**Triplecia*—Hall, Pal. New York, III, p. 522, 1859; Hall and Clarke, Pal. New York, VIII, pt. 1, p. 269, 1892.

**Triplecia extans* (Emmons)—Hall, Pal. New York, I, p. 137, pl. 33, fig. 1, 1847; Raymond, Bull. Amer. Pal., III, p. 304, pl. 19, fig. 4, 1902.

Zygospira—Hall and Clarke, Pal. New York, VIII, pt. 2, p. 154, 1893.

Zygospira recurvirostris (Hall)—Hall (*Atrypa recurvirostris*), Pal. New York, I, p. 140, pl. 33, fig. 5, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 161, pl. 10, fig. 23-26, 1903.

PELECYPODA.

Cyrtodonta—Billings, Geol. Surv. Canada, Rep. Prog. for 1857, p. 179, 1858; Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 534, 1897.

Cyrtodonta huronensis Billings—Billings, Geol. Surv. Canada, Rep. Prog. for 1857, p. 180, fig. 3, 4, 1858; Ulrich (*Cyrtodonta subovata*), Geol. Minnesota, Pal., III, p. 536, pl. 39, fig. 28-30, 1893.

GASTROPODA.

Hormotoma—Salter, G. S. C. Can. Org. Remains, Dec., I, p. 18, 1859; Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 959, 1897.

†*Hormotoma gracilis* (Hall)—Hall (*Murchisonia gracilis*), Pal. New York, I, p. 181, pl. 39, fig. 4a-e; pl. 83, fig. 1a, 1b, 1847; Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 1015, pl. 70, fig. 18-21, 1897.

**Hormotoma trentonensis*—Ulrich and Scofield, Hall, Pal. New York, I, pl. 39, fig. 1a (not 1a-1d), 1847; Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 1017, pl. 70, figs. 13, 14, 1897.

Liospira—Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 953, 1897.

**Liospira vitruvia* (Billings)—Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 995, pl. 69, figs. 3-8, 1897.

Raphistoma—Hall, Pal. New York, I, p. 28, 1847; Ulrich and Scofield, Geol. Minnesota, Pal., III, p. 934, 1897.

Raphistoma peracutum Ulrich and Scofield—Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, pp. 934, 940, 1897.

Raphistomina—Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 932, 1897.

Raphistomina modesta Ulrich—Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 943, 1897.

**Sinuites*, Koken, Die Leitfossillien, Leipzig, p. 392, footnote, 1896; Ulrich and Scofield (*Protowarthia*), Geol. Minnesota, Pal., III, pt. 2, pp. 848-867, Dall, Zittel-Eastman Textb. Pal., 2d ed., p. 521, 1913.

**Sinuites cancellatus* (Hall)—Ulrich and Scofield (*Protowarthia cancellata*), Geol. Minnesota, III, pt. 2, p. 872, pl. 63, figs. 1-14, 1897.

Trochonema umbilicatum Hall—Hall (*Pleurotomaria umbilicata*), Pal. New York, I, p. 43, pl. 10, fig. 9a-h; pl. 38, fig. 1a-g, 1847; Ulrich and Scofield, Geol. Minnesota, Pal., III, pt. 2, p. 1047, pl. 77, fig. 1-8, 1897.

CONULARIDA.

**Conularia*—Miller, Sowerby's Min. Conchology, III, p. 107, 1821.

**Conularia trentonensis multicosta* Ruedemann—Ruedemann, Bull. New York State Mus., 162, p. 115, 1912.

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Endoceras—Hall, Pal. New York, I, p. 58, 1847; Hyatt, Proc. Bos. Soc. Nat. His. XXII, p. 266, 1883.

Gonioceras—Hall, Pal. New York, I, p. 54, 1847; Clarke, Geol. Minnesota, Pal., III, pt. 2 p. 794, 1897.

Gonioceras anceps Hall—Hall, Pal. New York, I, p. 54, pl. 14, fig. 1a-d, 1847; Billings, G. S. C. Geol. Can., 1863, p. 150, fig. 108 a, b.

Nanno—Clarke, Amer. Geol. XIV, pp. 205-208, 1894; Grabau and Shimer, N. A. Index Fossils, II, p. 44, 1910.
Nanno kingstonensis Whiteaves—Whiteaves, Amer. Geol. XXXV, p. 27, pl. 3, 1905.
Orthoceras—Grabau, U. S. Geol. Surv. Bull., 45, p. 215, 1901.
**Orthoceras junceum* Hall—Hall, Pal. New York, I, p. 204, pl. 47, figs. 3a-f, 1847.
Orthoceras multicameratum Emmons—Clarke, Geol. Minnesota, Pal., III, pt. 2, p. 789, 1897; Walcott, Mon. U. S. Geol. Surv. VIII, p. 86, pl. 12, fig. 3, 1884.
Orthoceras recticameratum Hall—Hall, Pal. New York, vol. I, p. 46, pl. 11, fig. 1d, 1847.

TRILOBITA.

Bathyurus—Raymond, Bull. Vict. Mem. Mus. I, p. 51, 1913.
Bathyurus extans (Hall)—Hall (*Asaphus? extans*), Pal. New York, I, p. 288, pl. 60, fig. 2, a-c, 1847; Raymond, Ann. Carnegie Mus., VII, No. 1, p. 46, pl. 15, fig. 7, 8; pl. 16, fig. 5, 1907.
Bathyurus spiniger Hall—Clarke, Geol. Minnesota, Pal., III, pt. 2, p. 723, fig. 38-40, 1897; Raymond, Ann. Carnegie Mus., VII, p. 48, pl. 15, fig. 4-6, 1910.
Bumastus—McCoy, Ann. Mag. Nat. Hist., 2nd ser. IV, p. 399, 1849; Grabau and Shimer, N. A. Index, Fossils, II, p. 297, 1910.
**Bumastus bellevillensis* Raymond and Narraway—Raymond and Narraway, Ann. Carn. Mus., IV, p. 253, pl. 61, figs. 6, 7, 1908.
**Bumastus billingsi* Raymond and Narraway—Raymond and Narraway, Ann. Carnegie Mus., IV, p. 250, pl. 61, figs. 1, 2, 1908; Raymond, Geol. Surv. Canada, Mus. Bull., I, p. 34, pl. 3, fig. 12, 1913.
Bumastus milleri (Billings)—Billings, Can. Nat. Geol., IV, p. 375, fig. 10, 1859; Raymond and Narraway, Ann. Carnegie Mus., IV, p. 249, pl. 61, fig. 9, 10; pl. 62, fig. 3-5, 1910.
**Calymene*—Brongniart, Hist. Nat. Crust. Foss., p. 11, 1822; Grabau and Shimer, N. A. Index Fossils, II, p. 314, 1910; Slocom Field Mus. Nat. Hist. Geol., Ser. 4, p. 66, 1913.
**Calymene senaria* Conrad—Hall, Pal. New York, I, p. 238, pl. 64, figs. 3a-n, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 203, pl. 15, fig. 23, 1903.
Ceraurus—Green, Mon. Tril. N. A., p. 83, 1832; Clarke, Geol. Minnesota, Pal., III, pt. 2, p. 736, 1894; Cummings, 32nd Ann. Rep. Dep. Geol. Nat. Res. Indiana, p. 1051, 1908; Raymond and Barton, Bull. Mus. Comp. Zool., LIV, p. 527, 1913.
**Ceraurus dentatus* Raymond and Barton—Hall (*C. pleurexanthemus* in part), Pal. New York, I, p. 65, figs. 1d, h, i, m; pl. 66, figs. 1a-g, 1847; Raymond and Barton, Bull. Mus. Comp. Zool., LIV, p. 534, pl. 1, fig. 2; pl. 2, figs. 4, 5, 1913.
†*Ceraurus pleurexanthemus* Green—Hall, Pal. New York, I, p. 242, pl. 65, figs. 1a-c, 1e-g (not 1d, h, i, m, nor pl. 66, fig. 1a-f 1847=*C. dentatus*); Raymond and Barton, Bull. Mus. Comp. Zool., LIV, p. 528, pl. 1, fig. 1; pl. 2, figs. 1, 2, 7, 1913.
Illaenus—Grabau and Shimer, N. A. Index Fossils, II, p. 292, 1910.
Isotelus—DeKay, Ann. Lyceum Nat. Hist. New York, I, p. 174, 1824; Grabau and Shimer, N. A. Index Fossils, II, p. 291, 1910.
†*Isotelus gigas* DeKay—Hall, Pal. New York, I, p. 25, pl. 4 (bis), fig. 16; p. 231, pl. 60, fig. 7a-i; pl. 61, figs. 3a-m, 4a-c; pl. 62, figs. 1a-c, 2; pl. 63; p. 254, pl. 66, fig. 5, 1847; Weller, Geol. Surv. New Jersey, Pal., III, p. 192, pl. 14, figs. 6, 7, 1903; Raymond, Bull. Mus. Comp. Zool., LVIII, p. 248, pl. 1, figs. 1, 2; pl. 2, figs. 2-5, pl. 3, fig. 3, 1914.
Onchometopus—Raymond and Narraway, Ann. Carnegie Mus., VII, pp. 51, 63, 1910.
Onchometopus simplex Raymond and Narraway—Raymond and Narraway, Ann. Carnegie Mus., VII, p. 52, pl. 16, fig. 6-8, 1910.
Pterygometopus—Grabau and Shimer, N. A. Index Fossils, II, p. 323, 1910.

OSTRACODA.

Aparchites—Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 643, 1896; Grabau and Shimer, N. A. Index Fossils, II, p. 343, 1910.
Eurychilina—Ulrich, Cont. Micro-Pal. Geol. Surv. Can., pt. 2, p. 52, 1889; Cumings, 32nd Ann. Rep. Dep. Geol. Nat. Hist. Res. Indiana, p. 1040, 1908.
Isochilina—Jones, Geol. Surv. Can., Dec. III, p. 97, 1858; Grabau and Shimer, N. A. Index Fossils, II, p. 341, 1910.
Isochilina armata Walcott—Walcott, 35th Rep. New York State Mus. Nat. Hist., p. 213, pl. 17, fig. 10, 1884.
Isochilina subarmata Ulrich M. S.
Leperditella—Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 636, 1897.
Leperditella mundula (Ulrich)—Ulrich, Amer. Geol., X, p. 265, pl. 9, fig. 4-8, 1892.
Leperditella tumida (Ulrich)—Ulrich, Amer. Geol., X, p. 264, pl. 9, fig. 1-3, 1892.
Leperditia—Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 633, 1897; Grabau and Shimer, N. A. Index Fossils, II, p. 339, 1910.
Leperditia fabulites (Conrad)—Conrad, (*Cytherina fabulites*), Proc. Acad. Nat. Sci. Phil, I, p. 332, 1843; Ulrich, Geol. Minnesota, Pal., III, pt. 2, p. 634, pl. 43, fig. 10-14, 1897.

EXPLANATION OF PLATE I.[4]

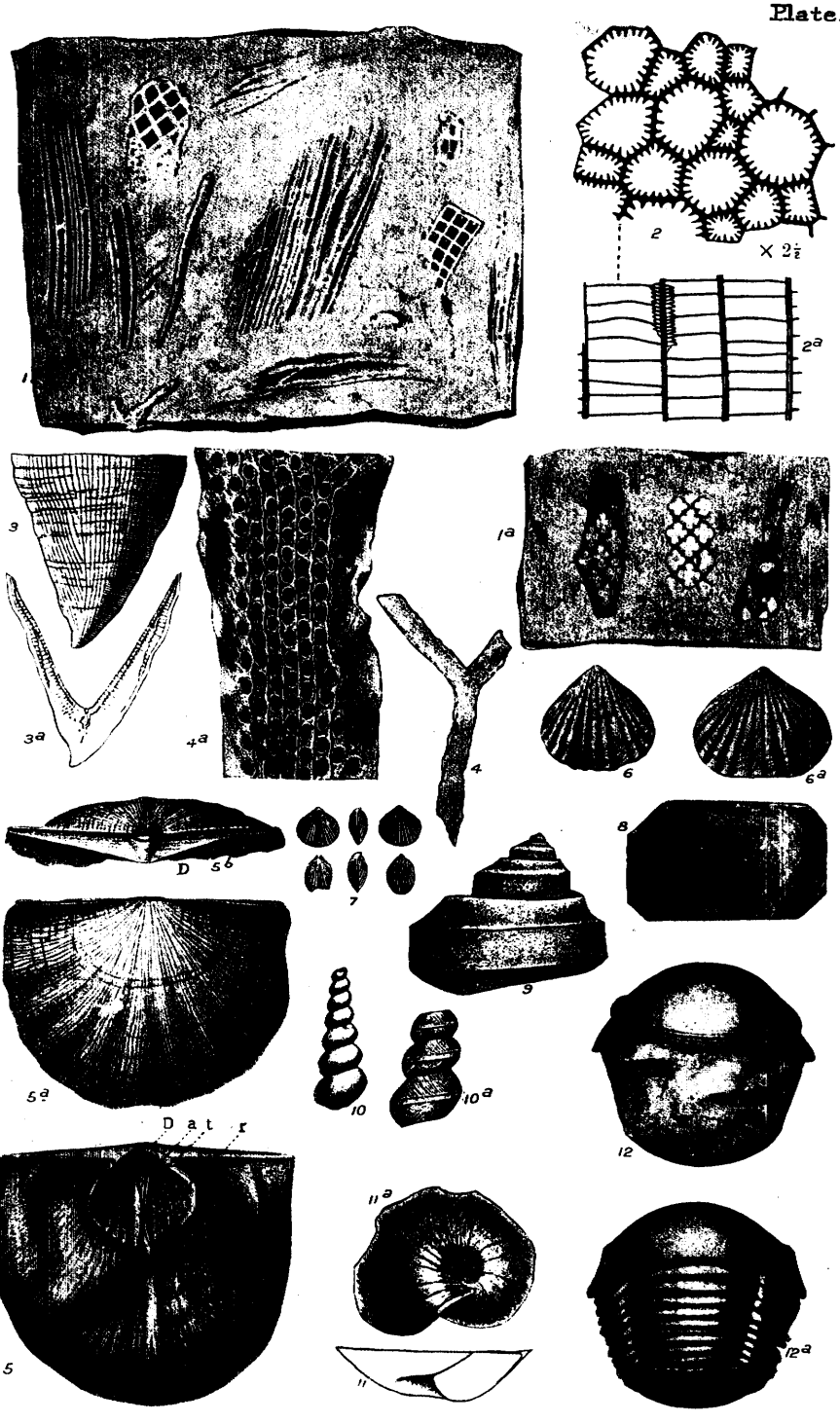
(Black River Fossils)

D—Deltidium, pedicle valve.
a—Posterior adductors.
r—Diductors scars.
s—Median septum.
t—Teeth.

1 and 1a. *Tetradium cellulosum* Hall.
2. *Columnaria halli* Nicholson. Cross section x 2½
2a. The same. Longitudinal section x 2½.
3 and 3a. *Streptelasma profundum* (Conrad) x 2½.
4. *Pachydictya fimbriata* Ulrich.
4a. Another specimen of the same x 9.
5. *Strophomena filitexta* Hall. Interior of pedicle valve.
5a. Another specimen of the same. Exterior of brachial valve.
5b. Cardinal area of another specimen.
6 and 6a. *Rhynchotrema increbescens* (Hall). Opposite views of two different specimens.
7. *Zygospira recurvirostris* (Hall). Pedicle, brachial and side views of two specimens.
8. *Cyrtodonta* sp.
9. *Trochonema umbilicatum* Hall. Cast of a specimen.
10. *Hormotoma gracilis* (Hall).
10a. Another specimen of the same, magnified.
11. *Raphistoma peracutum* Ulrich. Apertural view x 2.
11a. Umbilical side of the same x 2.
12 and 12a. *Bumastus milleri* (Billings). Two views of a small specimen x 4.

[4] All figures on this and succeeding plates are natural size except where otherwise indicated. With the exception of Plate I, fig. 8, all illustrations are reproduced from papers by Hall, Hall and Clarke, Lambe, Logan, Raymond, Raymond and Narraway, Ulrich, Walcott, Whiteaves.

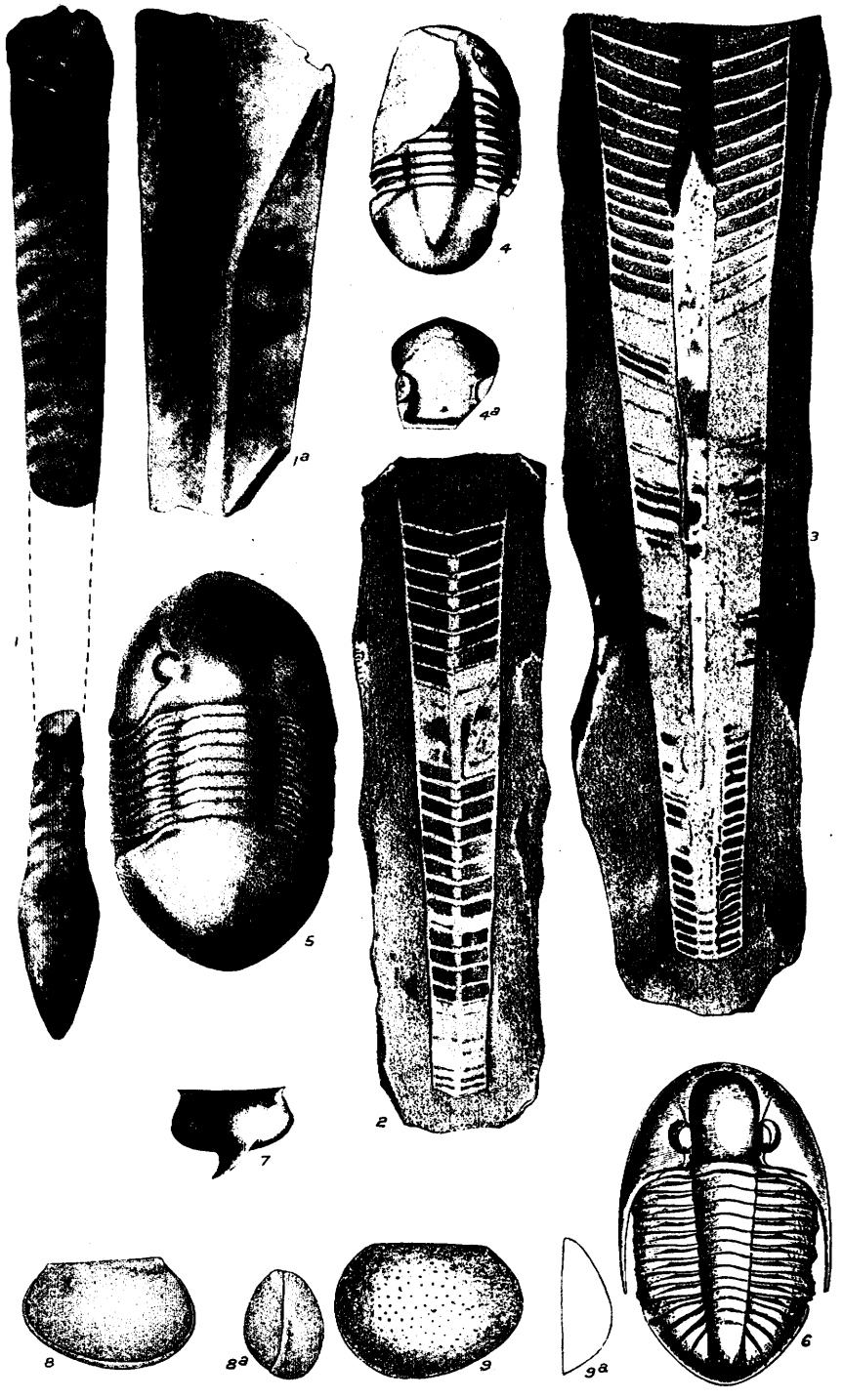
Plate I



EXPLANATION OF PLATE II.

(Black River Fossils)

1. *Nanno kingstonensis* Whiteaves. Prolonged portion of the siphuncle.
1a. Longitudinal section of the anterior end of a portion of the siphuncle of a large specimen of *N. kingstonensis.*
2. *Orthoceras recticameratum* Hall.
3. *Orthoceras multicameratum* Emmons.
4. *Onchometopus simplex* Raymond and Narraway.
4a. A cranidium of another specimen of the same.
5. *Isotelus gigas* DeKay.
6. *Bathyurus extans* (Hall).
7. *Isochilina armata* Walcott.
8 and 8a. *Leperditia fabulites* Conrad. View of the right side and posterior x 2.
9 and 9a. *Leperditella tumida* (Ulrich), enlarged.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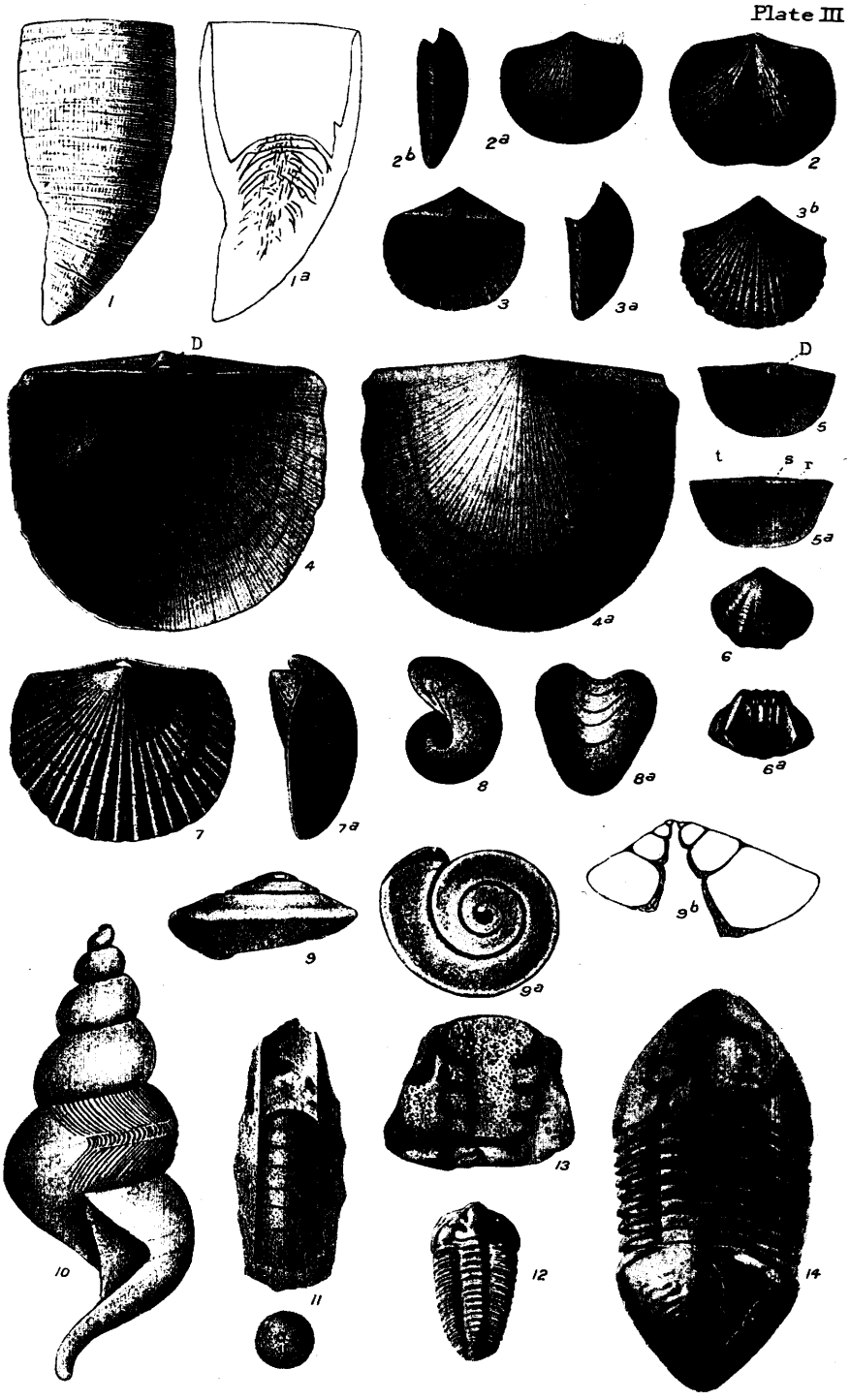
EXPLANATION OF PLATE III.

(Trenton Fossils)

D—Deltidium, pedicle valve.
a—Posterior adductors.
r—Diductors scars.
s—Median septum.
t—Teeth.

1, 1a. *Streptelasma corniculum* Hall. Side view and longitudinal section of one specimen.
2. *Dalmanella testudinaria* (Dalman). Exterior of a brachial valve.
2a. The same. Exterior of pedicle valve.
2b. Side view of another specimen.
3. *Orthis tricenaria* Conrad. Interior of a pedicle valve.
3a. Side view of the same species.
3b. Exterior of the pedicle valve of the same species.
4, 4a. *Rafinesquina alternata* (Emmons). Two views of the exterior.
5. *Plectambonites sericeus* (Sowerby). Brachial valve.
5a. Interior of the pedicle valve of the same species.
6, 6a. *Parastrophia hemiplicata* (Hall). Two views of the exterior.
7, 7a. *Dinorthis pectinella* (Emmons). A view of the pedicle valve and profile.
8, 8a. *Sinuites cancellatus* (Hall). Two views.
9, 9a. *Liospira vitruvia* (Billings). Two views of exterior.
9b. Cross section of a specimen of the same species.
10. *Hormotoma trentonensis* Ulrich and Scofield.
11. *Orthoceras junceum* Hall. A fragment and section of a shell.
12. *Calymene senaria* Conrad.
13. *Ceraurus dentatus* Raymond and Barton. Glabella of a large individual.
14. *Isotelus gigas* DeKay.

Plate III



INDEX VOL. XXV, PART III.

PAGE

Actinolite 3, 27
Addington co.
  Post-glacial deposits 24
Algoman.
  Building and paving stone 34
  Exposures of 25
    photo 14, 18
  Granite 9, 12-15, 27, 35
  Relation to mineral veins 33
  Storrington tp. 29
Altitude.
  Thousand Islands 21
Ami, Dr. H. M. 38
Amphibole 3
Analyses.
  Feldspar, Bedford tp. 28
  Gneiss, Round lake 4
    Barriefield 4
    Brewer Mills 8
  Granite 11
Anhydrite 3
Anorthite 3
Anthraxolite 34
Apatite.
  Kingston area 3, 27
    Large crystals of 30
    History of industry 28
    Origin 29-30
Archean.
  Iron deposits in 29
Arsenic 27
Arsenopyrite 3
Augite 16
Augite-diabase 15

Barite.
  Kingston area 3, 27, 33
    industry 34
    photo 33
Barriefield common, Kingston.
  Rocks, conglomerate 26
    gneiss 4, 25
    granite 35
    limestone 43-44
Barton, G. S. 54, 58, 61
Bassler, Prof. Ray Smith 58
Battersea, Kingston.
  Gneiss rocks 4, 25
Bear point. *See also* Wolfe island.
  Fossils at 53
Bedford station, Bedford tp., Frontenac co.
  Feldspar mining 27, 28
  Lime industry 34
Bell, Dr. Robert 29
Belmont gold mine, Cordova.
  Mineralization at 33
Beryl 3
Bibliography.
  Fossils, Kingston area 58-61
Big Dipper mine, near Massasaga lake.
  Mineralization 33
Billings, Elkanah 46-52, 57, 58, 60-62

PAGE

Biotite 3, 10
Biotite gneiss 5
"Birdseye" limestone 38
Black River formation.
  Kingston area 2, 38, 42
    Fauna 43
    Fossils 45-53
      bibliography 58-61
      plates 63, 65
      " , explanation 62, 64
    Limestone 35
      photos .....18, 35, frontispiece
    Ordovician, stratigraphy 40
Blake's quarry, Pittsburgh tp. 19, 26
Bog iron 3
Bonnycastle, Capt. R. H. 38
Brewer Mills, Pittsburgh tp.
  Limestone at 25
    analyses 8
    photo 7
Brick 27, 36
Building-stone.
  Kingston area 27, 35
    industry 34
Burgess tp. North.
  Mica mining 28
Bytownite 3

Calcite.
  Kingston area 3, 29, 30, 42
  Gangue in lead vein 32, 33
Cambrian 2, 37, 40
Canadian General Electric Co.
  Sydenham mica mine 30
Cartwright point, Barriefield.
  Gneiss at 25
Cataraqui river.
  Fossils on 47
Celestite 3
Cement. *See also* Portland Cement ... 27
Chalcopyrite 3
Chazy formation 38
Chemical analysis. *See also* Analyses.
  Metamorphosed rocks, value of 4
Chondrodite 5
Clarke, Prof. John M. 38, 59-62
Clay. *See also* Saugeen clay 22, 36
Cobalt area 1
Cobble stone. *See also* Paving stone. 34
Cold Spring corner, Wolfe island.
  Fossils at 53
Collins bay, L. Ontario.
  Fossils near 47
Collins lake, Storrington tp.
  Limestone near 25
Conglomerate.
  Kingston area 8, 16, 17
    exposures 26
Conrad, A. H. ..45-49, 53, 54, 57, 61, 62, 64
Copper 27
Corundum 3, 27
Coste, Eugene 29
Cummings, Dr. Edgar R. 61

PAGE
Cushing, Prof. H. P. ...2, 12, 14, 19, 20, 39

Dalman, J. W. 59
Davidson, W. B. M. 29
Dawson, Dr. G. M. 29
Dawson, J. W. 29
De Kay, J. E. 46, 47, 52, 54, 57, 61
Deadman bay, Barriefield.
  Conglomerate at 26
  Gneiss at 25
Deloro gold mine, Deloro.
  Mineralization, cause of 33
Diabase.
  Kingston area 15
    exposures 26
Dike (s) 11, 13, 15, 17, 34
Diopside 5
Dog lake, Storrington tp.
  Rocks near 19
Dolomite 3

Eichwald, Eduard 53
Ells, Dr. R. W. 29, 38
Emmons, Ebenezer 47, 54, 56, 59
Etheridge, R. Jr. 58, 59

Fairchild, Prof. H. L. 2, 19, 20
Feldspar.
  Cushing experiments 14
  Kingston area 13, 14, 27
    analysis 28
Ferric oxide 14
Fielding, B. F. 29
Flamborough tp. 23
Fluorite 3, 27, 34
Fort Henry, Barriefield.
  Fossils 47
  Rocks at 37
    conglomerate 26
    limestone 41
Fossils.
  Kingston area 38-44
    Absent in Black River limestone.. 36
    Bibliography by Wilson and Mather 45-66
"Fossil trees" 19, 26
Frontenac co.
  Feldspar mining 27
  Geological map 1, 2
  Rocks of 8, 19, 25, 26
Frontenac lead mine.
  Age and origin of deposit 33
  Vein, photos 31, 32
Frontenac Lead Mining & Smelting Co. 31, 32

Gabbro 15
Galena. *See also* Lead 3, 31
Garnet 3
Glacial drift 22
Glaciation.
  Eastern Ontario 21
  Kingston area 2, 3, 16-17
Gneiss.
  Kingston area 3, 7-9, 30
    analysis 4
    exposures 25
      (photo) 11, 21
    zinc in 32

PAGE
Gold 3, 27
Goldfuss, August 45, 49
Gordon, Joseph 26
Grabau, Prof. A. W. 59, 61
Granite.
  Analysis 11
Granite gneiss 10
Graphite 3, 5, 30
Green, Jacob 46, 49, 52, 54, 58
Grenville series.
  Distribution in Ontario 4, 17
  Kingston area 2, 5, 12
    exposures 25
    limestone 29
      (photo) 6, 9
    quartzite 7
      (photo) 6

Hall, J. 45-64
Harrington, B. J. 29
Hartington, Portland tp.
  Laurentian rocks at 10, 25
  Keweenawan 26
Hematite. *See also* Iron 3, 5
Hornblende 5
Hornblendic gneiss 8
Howe island 2

Ilmenite. *See also* Iron 3
Iron.
  In archean rocks 29
  Kingston area 3, 5, 27

Jackson's mill, near Kingston.
  Fossils near 48
  Limestone (Pamelia) 41
  Section 41
Jones falls, Rideau canal.
  Basaltic rocks at 34

Keewatin series.
  Kingston area 7, 11
  Ontario, definition and distribution.. 4
  Origin 3
Keewatin-Grenville iron formation 4
Keweenawan formation.
  Kingston area 2, 15, 16
    exposures 26
    road metal 34
Kindle, Dr. E. M.
  Ordovician limestones of Kingston area, report by 37-44
  Reference 1, 20
Kingston area.
  Fossils 38-39, 41-44, 49
  Geology, economic minerals, report by M. B. Baker 1-36
  Ordovician limestones, paper by E. M. Kindle 37-44
Kingston Brick and Tile Co.
  Saugeen clay 26
Kingston mills.
  Fossils at 38, 39, 48
  Rocks.
    conglomerate 26
    exposures 25
    gneiss 25
    limestone 40
    photo 18

PAGE

Knight, Cyril W. 4, 12
Koken, Ernst 60

Labradorian area, E. of Hudson bay... 21
Labradorite 3
Lake Iroquois 23
Lake Ontario.
How formed 21, 23
Lake Ontario park, Kingston.
Saugeen clay at 26
Lambe, Lawrence M. 58, 62
Lanark co.
Geological map 1
Laurentian 2, 3
Kingston area 2, 3, 4, 10-12
exposures 25
Lead.
Kingston area 27
History of industry 31
Origin of 33
Photos of ore specimen 32
Leeds co.
Geological map 1
Lennox co.
Post-glacial deposits 24
Leray formation.
Kingston area 40, 42
Fossils in 47, 48
Lime 27, 34
Limestone.
Kingston area, age of 4, 5
barite in 34
report by Kindle 37-44
zinc in 32
Lit-par-lit structure.
Kingston area 4, 11, 13, 32
exposures 25
photo 21
Little Falls, New York, U.S.A.
Limestone at 45
Loam.
Definition of 23
Logan, Sir William 28, 38
Loughborough tp.
Apatite discovered in 28
Galena discovered in 31
Geological mapping of 2
Gneiss in 25
Mica in 30
Lowville formation.
Kingston area 40, 42
Fossils in 47, 8
"Lowville limestone" 38

Macadam roads. *See* Road.
Marl.
Lennox and Addington co. 24
Marysville, Wolfe island.
Fossils near 44
Rocks near 48
Mather, Dr. K. F.
Fossils of Kingston area, paper by.45-66
Reference to.... 20
McConnell, R. G. 20
McNeill, W. K. 1
Mica.
Kingston area 10, 27
depth of deposits 31

PAGE

large crystals of 30
history of industry 28
origin 30
prospecting for 30
Micaceous gneiss 7
Military Surveys Branch, Dept. of Militia 1
Miller, Gerritt S. 60
Miller, Dr. W. G. 4, 12
Minerals.
Kingston area 3, 27-36
Mohawk valley, New York state.
Limestone of 45
Moine series, Highlands of Scotland .. 9
Molybdenite 3, 27
Muscovite 3

Narraway, J. E. ...46, 48, 52, 57, 61, 62, 64
Nepheline 3
New York State, U.S.A.
Potsdam sandstone of 19, 20
Nicholson, H. A. 49, 58, 59
Nickel 16
Nomenclature (geological).
Paleozoic 37
North Burgess tp. *See* Burgess tp. N.
Ontario.
Phosphate industry 28

Ordovician.
Kingston area 2, 34
barite vein in, photo 33
limestone, report by Kindle 37-44
stratigraphy 40
Ore Chimney mine 33
Orthoclase 3

Paleozoic.
Kingston area 1, 2, 16, 22, 37-44
exposures 26
Lead veins cutting 33
Pamelia formation.
Kingston area 39-42
Fossils in 45, 47, 48
Pander, C. H. 59
"Paragneiss" 9
Parks, Dr. W. A. 58
Paving stone. *See also* Road 34
Peat 24
Pegmatite dikes 13, 27
Perth road quarry (near Kingston).
Fossils 47
Perth Road village 25
Petrography.
Gneiss 5
Phlogopite 29, 30
Phosphate of lime. *See* Apatite.
Picton island, Thousand Islands 12
Pittsburgh tp.
Rocks of, limestone 25
sandstone 17, 18, 35
Geological mapping of 2
Pitts Ferry, Pittsburgh tp.
Conglomerate at 26
Plagioclase 3
Pleistocene.
Kingston area 2, 23
brick industry 36
exposures 26

PAGE

Porcupine gold area 1
Portland tp., Frontenac co.
Geological mapping of 2
Rocks of.
crystalline limestone, photo 6
gneiss 25
quartzite, photo 6
Potash.
Percentage in feldspar 13, 27
Portland Cement. *See also* Cement.
Lennox and Addington co. 24
Potsdam formation.
Kingston area 2, 16-20, 35, 37, 40
sandstone, photo 17
Pre-Cambrian 1, 2, 37
Pyrite 3, 27
Pyroxene.
Kingston area 3, 29, 30
large crystals of 30
Pyroxenites.
Mica and phosphate deposits found in 29, 30
Pyrrhotite 3

Quartz.
Kingston area 3, 5, 13, 14
industry 27
Quartz (milky) 3
Quartzite 6, 7, 17
Queen's University, Kingston.
Photo of Geology and Mineralogy building .....Frontispiece

Ramsay lead mine, near Carleton Place.
Age of deposit 33
Rathbun Co. 24
Raymond, Dr. P. E. 39, 45, 46, 48, 52, 54, 57, 58, 61, 62, 64
Renfrew co.
Geological mapping of 1
Richardson feldspar mine, Bedford tp.
Analysis of feldspar 28
Rideau beds 40
Rideau canal.
Granite on east side of 10
Keweenawan trap rocks 26, 34
Limestone 42
Rideau Mining Co. 28
"Rideau sandstone" 38
Road.
Keweenawan trap, suitable for macadam 34
Rogers, W. R. 1
Round lake 4
Royal Military College, Kingston 1
Ruedemann, Rudolph.....2, 54, 57, 60
Rush bay, Wolfe Island 39
Rutile 3

Safford, J. M. 49, 58
Salter, J. W. 53, 54, 60
Sandstone 17, 35, 37
Saugeen clay.
Kingston area 22, 24
brick industry 36
exposures 26
photo 23

PAGE

Scapolite 3, 30
Schist.
Kingston area 3, 5, 30
exposures 25
School of Mining, Kingston 1
Schuchert, Charles 38, 60
Scofield, W. H. 48, 49, 54, 60
Selwyn, Dr. Alfred R. C. 29
Shannon toll gate.
Fossils at 43
Shimer, H. W. 61
Sowerby, James 54, 56, 59, 60
Sphene.
Kingston area 3
large crystals of 30
Storrington tp.
Geological mapping of 2
Rocks of 19, 25, 29, 34
exposures 26
photo 19
Syenite 12
Sydenham, Loughborough tp.
Mica at 30

Talc 3, 27
Thousand Islands region.
Glaciation 21
Notes by Cushing 12, 14
Timiskaming series.
Southeastern Ontario 12
Topography 16, 18, 26
Trachyte 5
Trap rocks, Kingston area.
Exposures 26
Photo 15
Use for road material 34
Trenton formation 2
Kingston area 2, 40, 43
Exposures 44
Fossils of 45, 53-58
bibliography 58-61
Trenton Falls, New York, U.S.A.
Limestone at 45

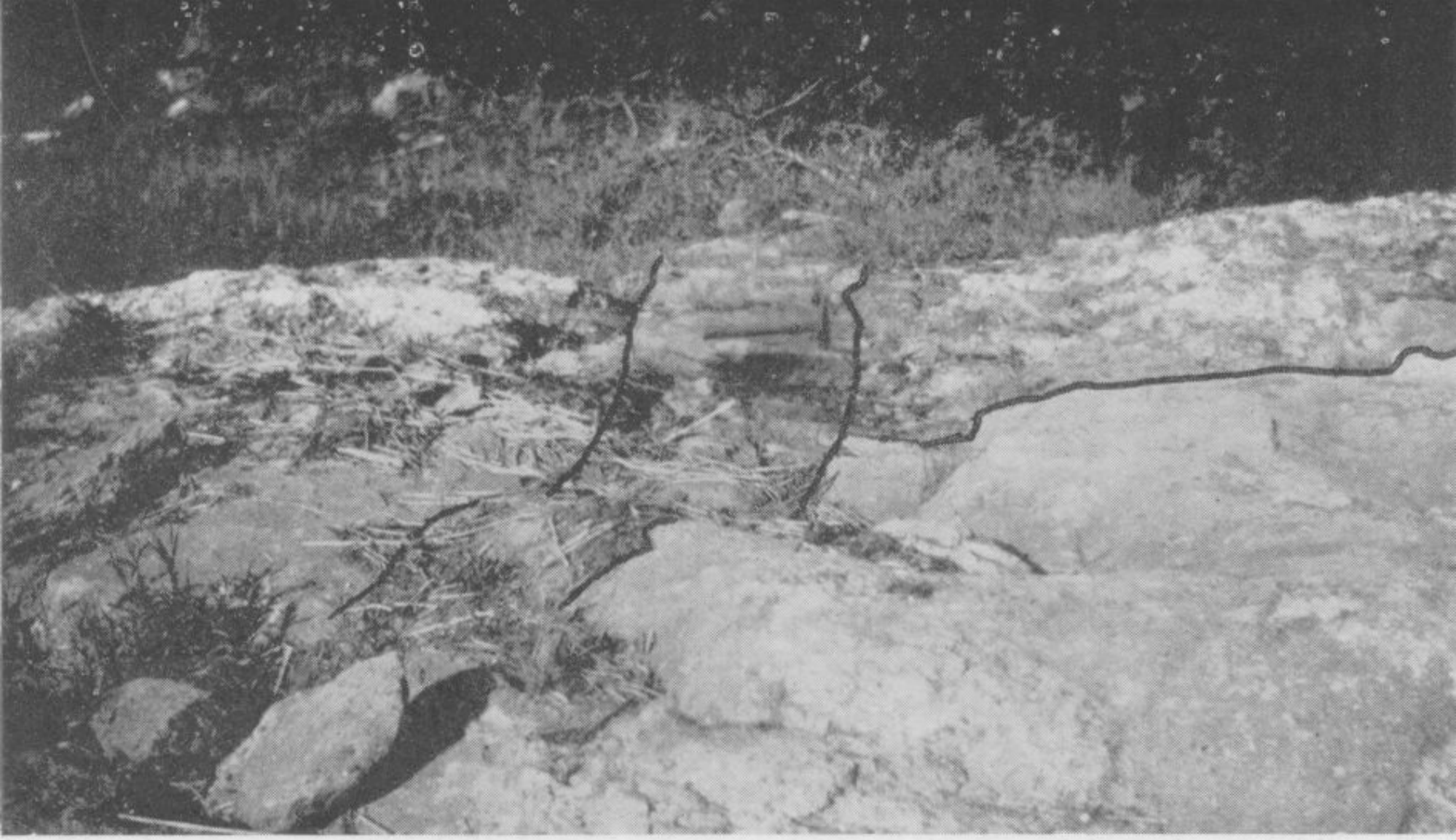
Uglow, Dr. W. L. 30
Ulrich, Dr. E. O. 39, 42, 43, 45-51, 53-55, 57-62, 64, 66

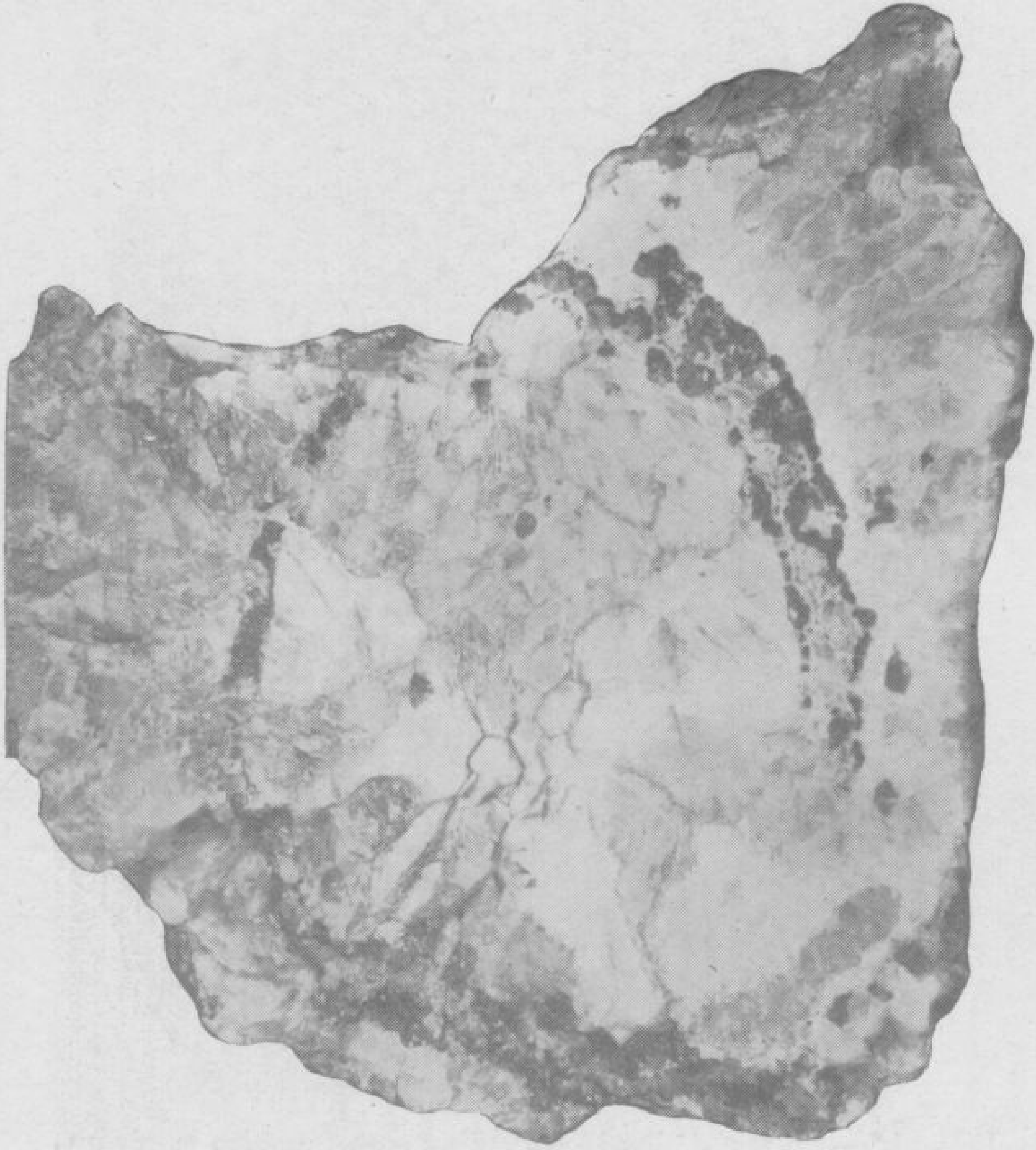
Vanuxem, L. 39
Venner, H. G. 28, 29
Verona, Portland tp.
Feldspar mining 27
Lime industry 34
Limestone and gneiss at 25
Vesuvianite 5

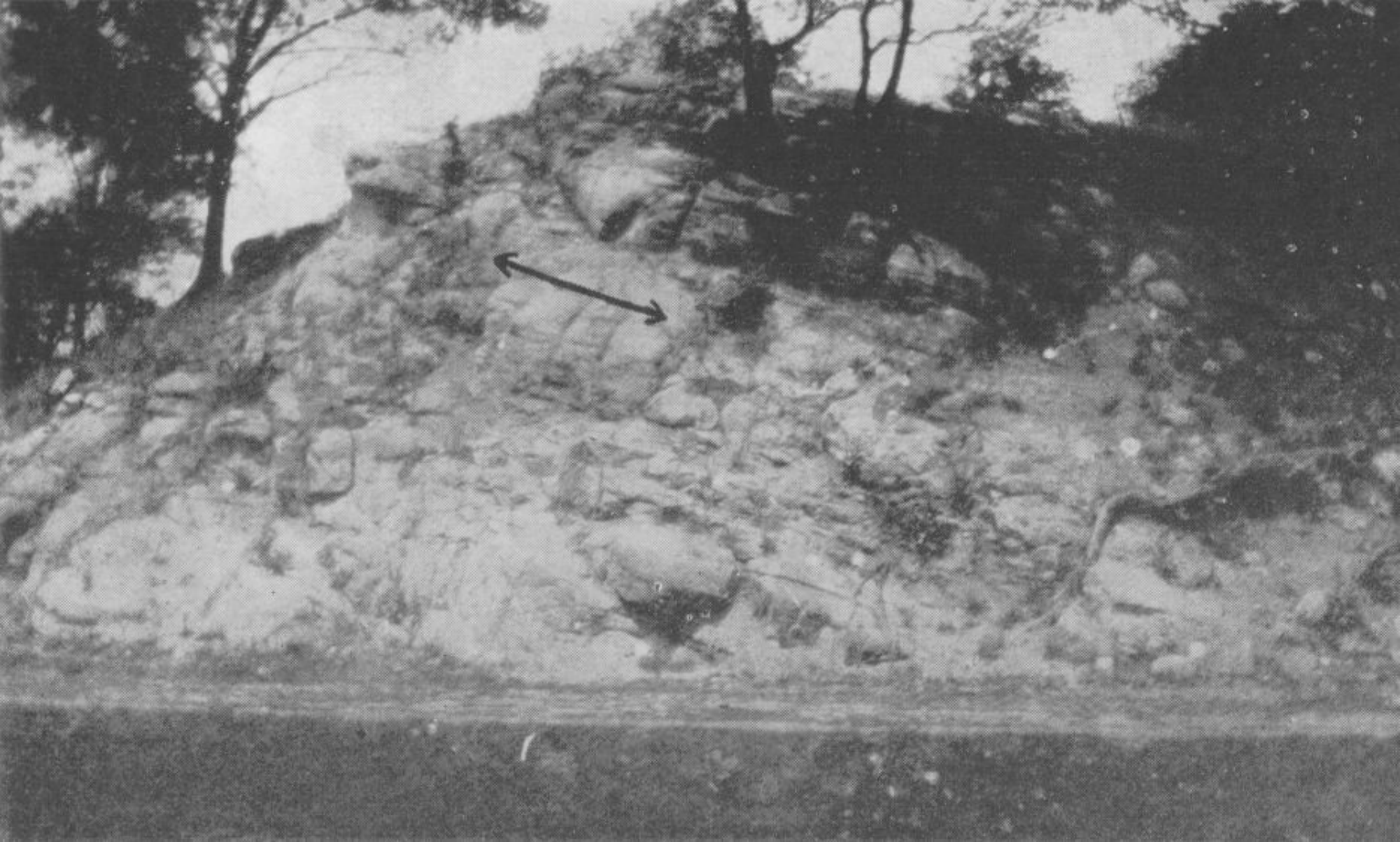
Wallcott, Dr. C. D. 53, 61, 62
Washburn, Rideau canal.
Rocks at 10, 34
exposures 26
photo 14
Watertown, E. Flamborough tp.
Beaches at 23
Watertown formation 40, 42
Watertown, New York, U.S.A.
Limestone at 45

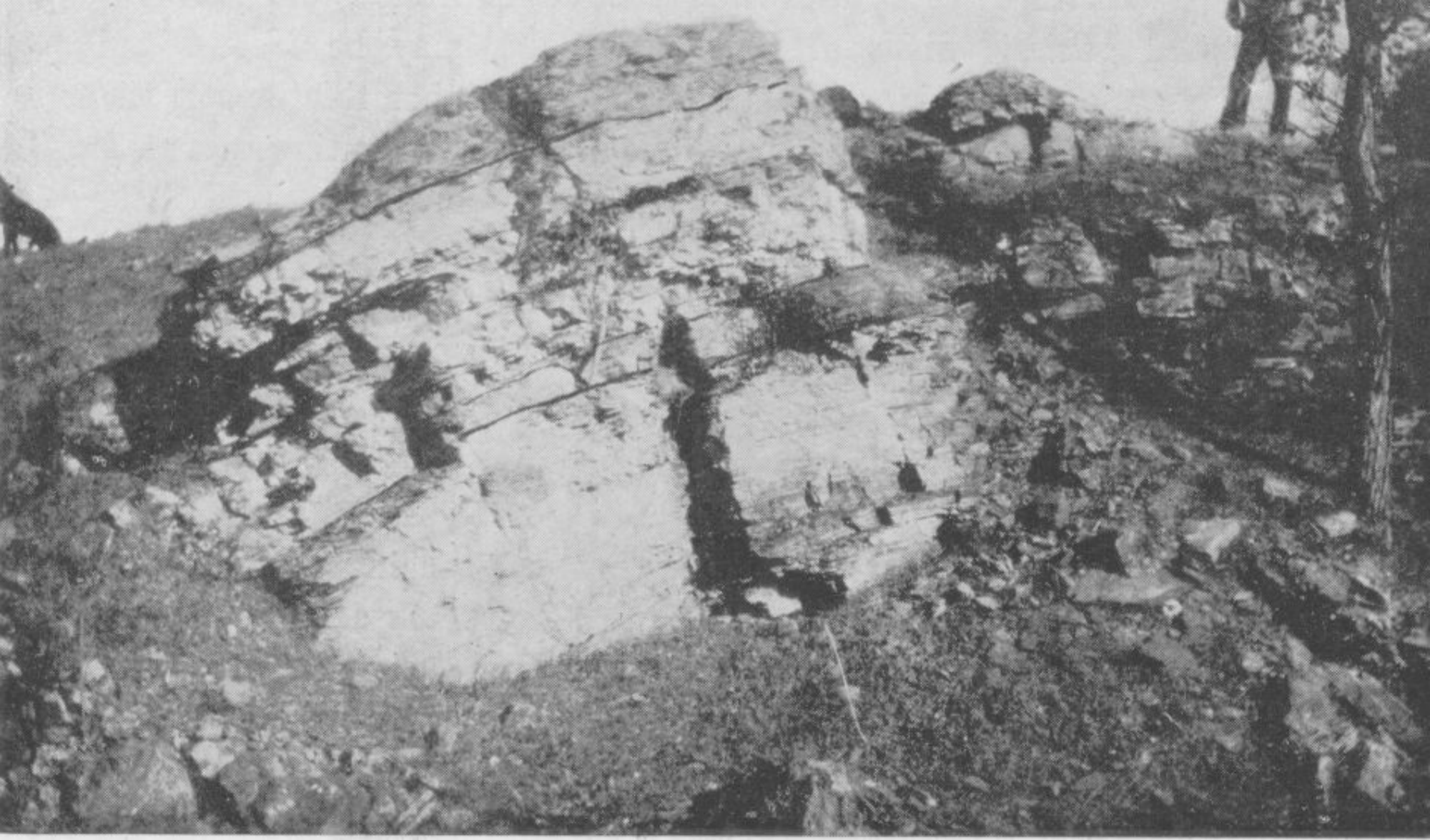
PAGE
Weller, Stuart 59, 60, 61
Whiteaves 46, 52, 61, 62, 64
Wilson, Alice E.
Fossils of Kingston area, report by. 45-66
Reference 20
Wilsonite 3
Winchell, N. H. 48, 50, 58, 60
Winchester, N. H. 46
PAGE
Wolfe island, L. Ontario.
Fossils on 45, 48, 53
Rocks on 2, 39, 43
Zinc.
Kingston area 3, 27
industry 32
Zircon.
Kingston area 3
large crystals of 30

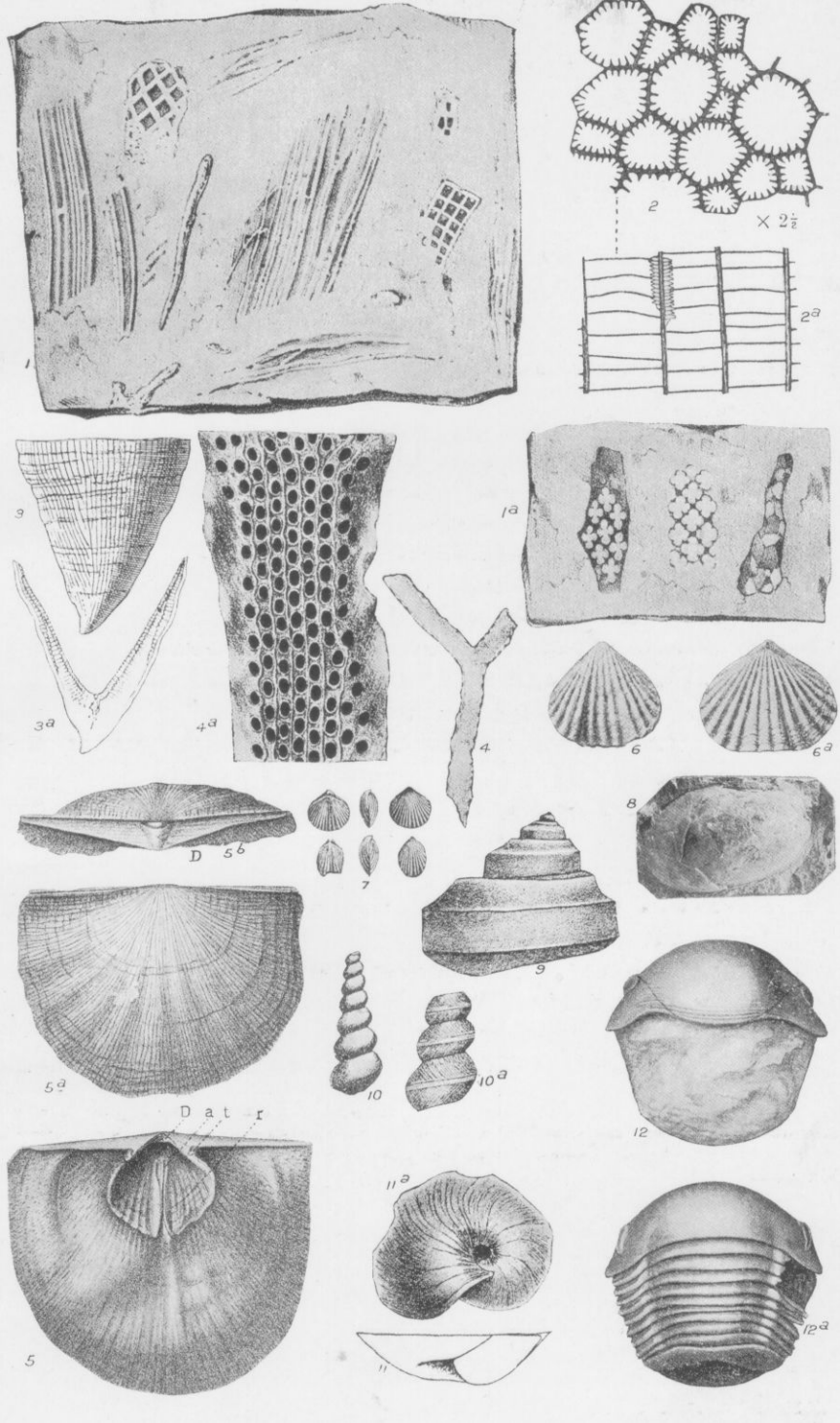
End of Part III.







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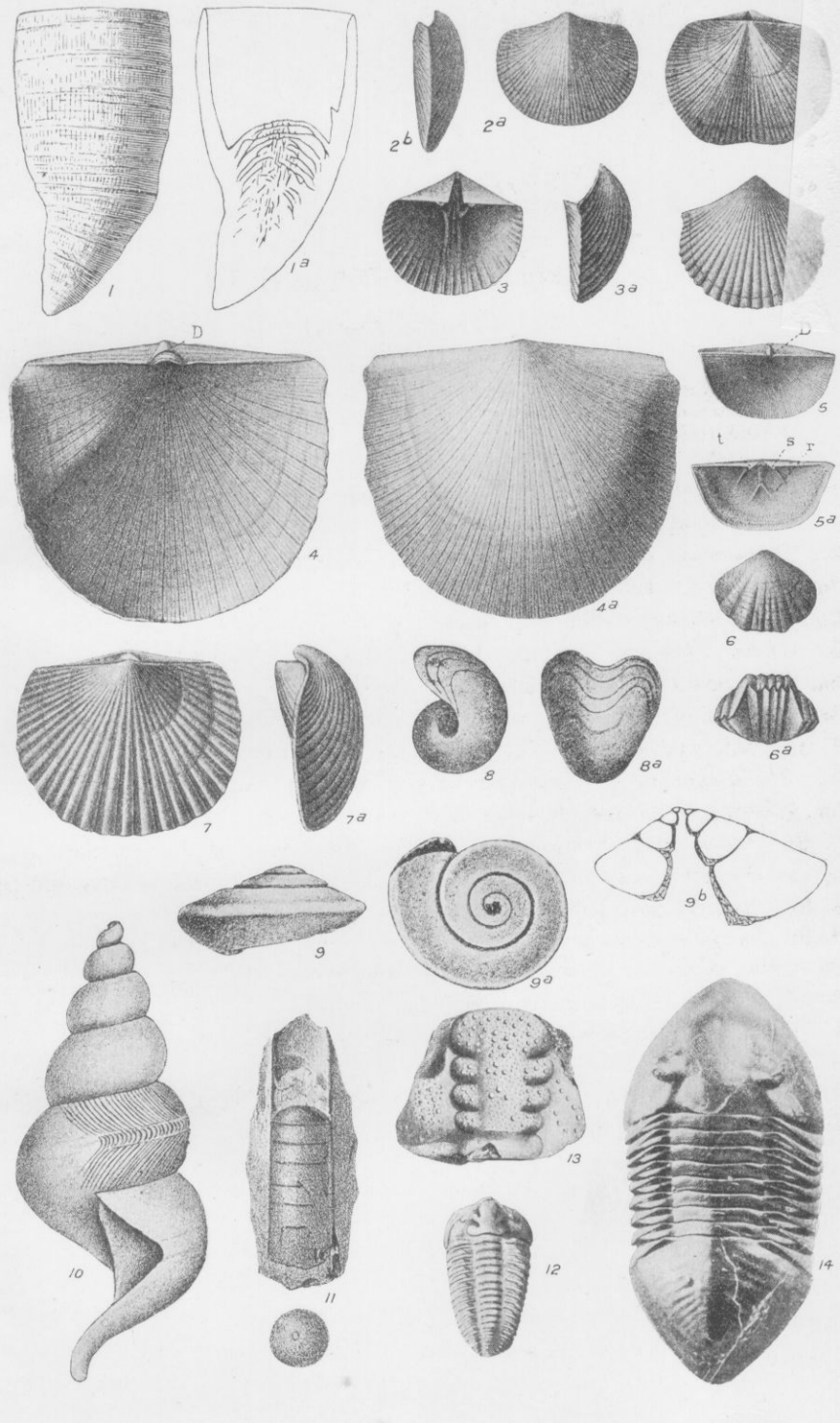
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